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The Debt of Transcontinental Telephony to Metallurgy.

The opening of the telephone line from New York to San Francisco on January 25 is one of the most noteworthy engineering achievements of recent times and sincere felicitations from every American engineer are due to Mr. John J. Carty, chief engineer of the American Telephone & Telegraph Company, and his able engineering staff. To the readers of this journal this event signifies again the interrelation of arts and sciences and especially emphasizes the fact that after all every new engineering undertaking must rely very largely on metallurgical progress. A few figures on the New York-San Francisco line are suggestive. The length is 3400 miles so that during any telephone conversation 6800 miles of wire are reserved exclusively for the speakers at the two ends. There are four hard-drawn copper wires of No. 8 B.W.G. gauge, from which two physical circuits and one phantom circuit can be derived. The total weight of copper in one circuit of two wires is 1480 tons. Of course, the whole thing would have been impossible without the high-conductivity copper obtained by electrolytic refining. But this was not enough, as Pupin's induction loading coils play an important part in the transmission, and in the construction of these coils iron plays an important part and the iron must have very peculiar properties; it must be as fine as a hair (0.004 inch in diameter) and must be insulated at that, and it must have very distinct electrical and magnetic properties. Some of the very best metallurgical talent in the world was employed in the solution of the problems involved. The work of designing and erecting the line has been enormous, but the achievement has been commensurate with the efforts.

Progress in Ore-Dressing in 1914

In the development of the art of ore-dressing during the past year, two tendencies were most distinctly marked. The first of these was in the direction of increasing the size and capacity of units of concentrating machinery. The second was the adaptation of flotation processes to an increasing number of types of ore.

The Utah Copper Company has for some time been making use of double-deck roughing tables having a very large capacity. The rough concentrate from a number of these tables is cleaned on a single table of the Wilfley type. A number of manufacturers are now offering special types of tables having unusually large capacity. One of the most interesting plants using a new type of an old machine is the slime concentrator of the Anaconda company, where twenty-deck buddles were installed for the purpose of handling large quantities of low-grade slime at low cost.

The engineers responsible for the development of concentration methods that have made possible the exploitation of the low-grade copper ore of the Utah Copper Company, designed a mill on similar lines for the treatment of the low-grade gold ore of the Alaska Gold Mines Company. This application of modern copper concentrating methods to gold ore is one of the most interesting developments of the year, but the conditions are unusual and the venture is expected to prove successful. The Alaska ore is amenable to this method of treatment because the gold occurs almost entirely in coarse particles. Jaw and gyratory breakers will be used for coarse crushing, and two series of rolls will finish the grinding prior to rough concentration. The next step in grinding will be done by tube or pebble mills, followed by the usual methods of concentration and amalgamation applicable to finely ground material. It will be observed that the almost universal practice of using stamps in connection with so-called free-milling gold ores has been abandoned in this instance.

Flotation concentration has now been in use by the Butte and Superior Copper Company long enough to demonstrate that the process, as specially modified by J. M. Hyde to fit the needs of that ore, is a marked success. Not only has the percentage recovery been increased by the adoption of the process, but the grade of concentrate also has been raised. It is understood that a special adaptation of flotation concentration has been developed at Anaconda to supplement the general milling scheme. The results are such as to make flotation appear a close competitor with the roasting-leaching process already perfected by the company's staff, and for which a 2500-ton plant has been erected. It is possible that flotation may be adopted for treating slime of current production, leaving the old accumulations to be treated in the leaching plant.

Experiments with flotation processes have been conducted by many prominent, and even minor, companies during the past year, and it is likely that the coming year will see a wider adoption of the process. It is expected that new installations in the large copper mills will effect so much higher recovery than is now being made as to materially augment copper production in the Rocky Mountain and Southwestern regions. Some engineers confidently see the doom of the vanner in the success of flotation, and if this be accomplished no one will regret to see the abandonment of the acres of vanners now necessary to handle the slime in the large copper mills.

A number of American engineers are contributing to the development of the art of flotation concentration. Mr. J. M. Callow has brought out a machine in which the air necessary for flotation of the oiled sulphides is introduced into the pulp under pressure through a canvas diaphragm. Mr. John D. Fields is sponsor for another process that has been tested in a number of mills, and was to have been adopted experimentally by the Ohio Copper Company, if that concern had not been overtaken by financial troubles. Mr. Henry E. Wood has developed still further his machine for surface-tension flotation, which is successfully applied to a number of types of sulphide ore. Mr. J. H. Haynes has made some novel improvements that look promising, having given encouraging experimental results. The Macquisten process has been in profitable operation at the Morning mill of the Federal Lead Company, at Mullan, Idaho.

In Australia, Horwood, Lyster and Bradford have brought out special modifications of practice for making a differential separation of sulphides.

Another modification of oil concentration, the Murex process, has been adopted on a commercial scale abroad and is being tested in this country. In this process finely ground magnetite is mixed with oil, which is then thoroughly mixed with the ore pulp to be treated. The presence of the magnetite in the oil permits the oiled metalliferous minerals to be removed by means of an electromagnet. The special field for this process seems to be in concentration of oxide and carbonate ores of lead and copper, and possibly in the differential separation of galena, pyrite and blende. In Germany it has been used successfully for recovering fine galena from slime containing much heavy spar. In Spain it is being used for the concentration of copper carbonates and oxides. Another patented scheme for floating oxide and carbonate ores involves their prior conversion, superficially, at least, into sulphides by treatment with hydrogen sulphide.

The art of flotation concentration should be rapidly developed when the status of flotation process patents is finally determined through the litigation now pending. Minerals Separation has succeeded in getting the United States Supreme Court to review the decision of the Ninth Circuit Court of Appeals in its case against James M. Hyde, and when the final decision is given, metallurgists will draw a breath of relief and progress will be rapid. It is regrettable that our patent procedure is so frightfully cumbersome.

Broadly speaking, the art of ore-dressing is becoming more complicated and more highly developed, and is constantly making it possible to treat materials that formerly were outside the realm of concentration. Professor Robert H. Richards has suggested that great profit is to be gained by placing high-class men in charge of the classifier departments of mills. In this regard it is certain that as we adopt new processes depending on principles not hitherto used, it will be more and more essential to employ high-class men in charge of ore-dressing operations; men who thoroughly understand what they are trying to accomplish, who know the principles involved, and who are capable of checking their work by the most carefully conducted tests.

A Failure in Coking Coal Land Speculation

Since January 18 the county court of Fayette County, Pennsylvania, at Uniontown, has been busy appointing receivers. On that date the First National Bank of Uniontown was closed by the federal banking authorities and immediately thereafter the receiverships began, for Josiah V. Thompson and many of his associates. Mr. Thompson's liabilities are stated at $22,000,000 while his assets are rated at $70,000,000. The interrelations of Mr. Thompson, his associates and various

corporations are so intricate and manifold that even a brief outline cannot here be attempted. There were partnerships, mortgages, options, promissory notes and other arrangements so extensive that Mr. Thompson, the central feature in all, and the president of the bank that was closed, is said to have been held at work twenty hours a day for a long time past keeping the financial and other machinery in operation. Finally the break came and it may be years before all settlements are completed.

While the structure that has been placed under the protection of the law until the engineers can repair its weak points or dispose of its parts is very complicated, the principle underlying the involvement is simple. Changes have occurred in the practices and ambitions of the steel trade of which the Thompson party was ignorant or became cognizant of when it was too late to protect themselves. A precedent was trusted when conditions had changed.

Mr. Thompson was a speculator in coking coal lands and carried with him almost the entire community which had money to invest. Almost the entire acreage in the regular Connellsville or "old basin" was acquired many years ago by merchant-coke interests or blast-furnace interests at relatively low prices per acre. In the latest period of its exploitation a few fortunes were made by farmers who had not earlier sold out. Just at the close of the last century the expanding needs of the iron industry required more coke and the lower Connellsville or "Klondike" was opened, and many fortunes were made. It was the spirit of the times that a large consuming interest should be provided with its raw materials for many years to come, and soon the Klondike was entirely pre-empted. Mr. Thompson, who had been prominent in the development, then turned his attention to the recognized extension of the seam across the Monongahela River into Greene County, believing that as the iron industry expanded it would be necessary for this coking coal also to be developed. His early purchases were at relatively low prices and his sales were by no means unimportant. They profited him while the buyers found themselves in fair position to ship coal or make coke. Year by year, however, Mr. Thompson paid higher and higher prices, whether to protect his market in selling coal acreage or through belief in the inherent value of the purchases it may not be safe to attempt to judge. The total acreage in which he is now interested directly or indirectly is estimated at not far from 200,000 acres in coal seams that promise to yield from 7000 to 9000 tons of coke per acre. This represents an amount of coke equal to the maximum shipments of the Connellsville and lower Connellsville regions for about three-quarters of a century.

In recent years the carrying of these speculative holdings has been expensive. It was necessary either that frequent sales should be made from the aggregation, at good profits, or that the recognized value of the coal, from the banker's standpoint, should increase steadily so that borrowings could be increased. Of late the sales have been infrequent and it seems to have been impossible to negotiate additional loans.

The operation was well planned in the light of fifteen years ago, for then there was no recognized competition for the Connellsville coking coal seam. It was the disposition of large blast furnace interests to fortify themselves for the future by acquiring ore and coking coal in the ground. The beehive-oven practice of the day naturally involved the acquisition of a large track of coking coal in the ground, for the ovens were located over the coal and enough coal had to be provided to give them a fair life.

While the development of by-product coking has involved many sad experiences, showing that the retort ovens also have their requirements as to the character of the coal to be carbonized, it is well established that the retort oven can draw from many districts, and of particular importance is the fact that since the retort oven is always located at the blast furnace, for well-known reasons, it is immaterial whence the coal comes so long as it is of the proper quality. Indeed, the builder of a by-product plant may prefer not to purchase a coal acreage at any price, but rather to remain independent and select his fuel as he proceeds—and learns.

The coal-shipping industry, being overdeveloped already, has not permitted any large development at anything but rock-bottom prices for the coal seam, and thus there has been little absorption of Greene County coal in that direction. It may be mentioned that one of Mr. Thompson's earliest customers, and his largest, the Pittsburgh Buffalo Company, has been in receivers' hands for some time. As to the use of the coal for coking purposes, styles have changed in the industry and therefore the object for which the Thompson coal holdings were accumulated could not be successfully carried out.

Apart from these purely technical considerations, it is well to reflect that there must be a limit somewhere to the activities of a steel-producing company. Even a corporation cannot do everything and do it well. Twenty years ago it was common for one company to make the coke and another to mine the ore. A third interest transported the ore, and a fourth interest quarried the limestone. Then the blast furnace assembled its raw materials and sold pig iron. There were steel mills that bought pig iron and sold billets, and "finishing mills" that rolled the steel. Since then vertical integration has become the rule. But the steel mill does not stop in its finishing where it stopped ten years ago. One prominent steel producer builds railroad cars. Several make cold-rolled shafting, car axles and the like. The largest steel-producing company in the world makes and sells automobile-engine flywheels. All the steel producers are called upon for heat treatment and for alloy steels. There is plenty to keep them busy, and to absorb their capital, without their mining coal or investing in coal lands. There was a time when such investments seemed necessary for defense but that time is past. Whether the Uniontown party did not know this, or acquired the information too late for it to be of service, is a detail in which the general public has no particular interest.

Readers' Views and Comments

Carbon Determination by the Combustion Method

To the Editor of Metallurgical & Chemical Engineering.

A good scheme to reduce the cost of the determination of carbon in all metals and alloys in which the combustion method is used is as follows. The combustion boats after being used once or twice are no good for further use, but if they are cleaned of the insoluble fused mass, left after a carbon determination, they can be used again.

Several chemical houses have on sale electric polishing heads which with a high velocity (2000 to 3000 revolutions per minute) and fitted with a small emery wheel, the edges of which must be rounded, can be used to advantage to grind the fused mass out of the boats so that they can be used again. This wheel does not get into the end of the boat, but the small amount of the fused mass that is left, being carbon-free, would not vitiate the results.

These combustion boats are usually imported. With the grinding head, and with proper care in cleaning, one boat can be used to determine a great number of carbons. Care must be taken in cleaning them not to let the emery wheel touch the ends of the boat, for this would cause them to break and chip.

Wm. W. Jennings.

Electro Metallurgical Co., Glen Ferris, W. Va.

Comparisons of Electric Resistivities at High Temperatures

To the Editor of Metallurgical & Chemical Engineering.

Sir:—My attention has just been called by a friend to a draughtsman's error in chart 2 of my article, under the above heading, page 24 of your January issue, which I desire hereby to correct.

The curve for lead in chart 2 should of course correspond with the one in chart 1, hence the line approaching the short vertical melting point line should have been drawn to the bottom instead of the top, and the line after the melting point should have been drawn from the top instead of the bottom. The vertical line itself is correctly placed.

As this curve for lead is reproduced in chart 2 from chart 1 merely to show the proportions of the two scales, the error is not important except in that it gives the impression that the resistivity of lead falls upon melting, like bismuth, while as a fact it rises, as is correctly shown in chart 1.

Bismuth, antimony and perhaps Rose metal are the only three of the metals which fall at the melting point, all the others rising. It may be, however, that some of the non-metallic materials like those in charts 3, 4 and 5, fall upon melting, like bismuth; no data confirming this have come to my attention.

Carl Hering.

Philadelphia, Pa.

High Temperature Experimental Furnace

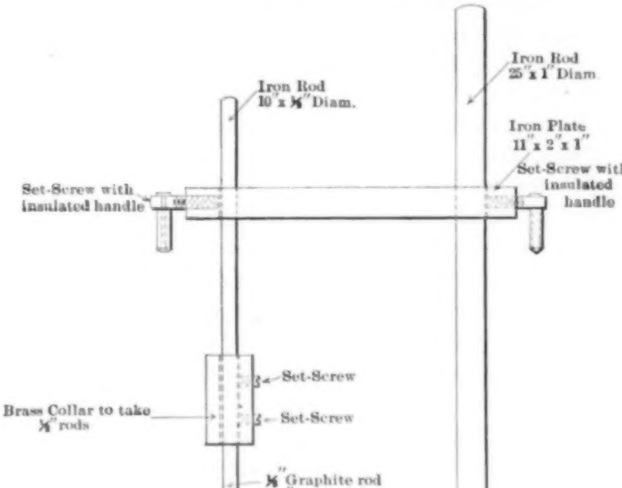
To the Editor of Metallurgical & Chemical Engineering.

Sir:—The following article describes a very simple and easily constructed experimental arc furnace which came under my observation while visiting the high-temperature laboratory of the Noble Electric Steel Company, at Heroult, Shasta County, Cal.

The furnace is especially adapted for the fusion of ferro-alloys, the melting point being reached within several seconds after applying the current.

The accompanying figure shows the furnace in its simplest form.

The base consists of a slab of any suitable refractory insulating material such as slate or marble. The standard is made by bolting an iron rod to the base at one end. A sliding arm, held in place by a set screw, holds the adjustable electrode. This electrode, which consists of a rod of graphite or carbon, slides through a hole in the bottom of an inverted 20-gram assay crucible



EXPERIMENTAL ELECTRIC FURNACE.

until it reaches within any desired distance from the bottom electrodes. The crucible serves the double purpose of protecting the eyes of the operator from the rays of the arc, and at the same time stopping any circulation of air which would tend to oxidize the electrodes. The bottom electrode is also made of graphite or carbon but in the shape of a disk in which is cut a cup for receiving the charge. Insulated handles of hard rubber are put on the set-screws so that the electrode can be raised or lowered while the furnace is in operation.

The furnace may be used on 110 or 220 volts taking from 30 to 50 amp while giving a ½-in. arc.

On starting a fusion it is better to cover the charge with powdered charcoal so that the crucible will fill with hot gas at the instant that the arc jumps.

Walter R. Malm.

San Francisco, California.

Tube-Milling Tonnage Calculation and Notes on Tube-Milling

To the Editor of Metallurgical & Chemical Engineering.

Sir:—Fine grinding efficiency in tube mills, although of such universal importance, has thus far not proved

amenable to mathematical treatment, and although many other operations in the cyanide process are susceptible of fairly exact mathematical expression, tube-milling at all plants is, in the early stages of their operation, experimental. Many disconnected data are scattered throughout the technical press and although it is useful, the time would seem to have arrived when some of the phases of this problem could be given mathematical form. As a step in the right direction, Mr. Cunningham's contribution on page 22 of your January issue should create a lively interest, and it is hoped it will elicit much helpful discussion.

From Mr. Haynes' remarks I am forced to conclude that he does not consider the advantages of the closed circuit as by any means well settled, and were many others of a like opinion, Mr. Cunningham's contribution would be of little interest. However, I do not think Mr. Haynes' attitude is shared by any great number of cyanide operators and I do not feel that an analysis of his arguments will bring many to his point of view.

Mr. Haynes errs in placing too much weight upon *percentage* as a factor of gross tube-mill feed. What the operator is after is the percentage of the initial feed (net feed) which is ground to the desired fineness, and what gross feed the tube-mill handles is of very minor consequence to him as long as he feels he is securing a satisfactory net result. Theoretically, the tube mill should do its best work when it is relieved of the slime as soon as possible after it is produced, and this is the effect of the closed circuit from the very reason that the circulating feed (gross feed) is so large in proportion to the net feed.

To make this clear, let us add another line to his table II to exhibit the time element. The charge will maintain a substantially even level within the mill under all conditions, being determined by the level of the discharge opening, and any increase in gross feed will reduce the time any given particle is within the mill. The figures added to Mr. Haynes' table (we may conveniently call them minutes) have been based on this assumption, 80 tons being taken as 100 minutes, 109 tons as $80/109 \times 100 = 73$ minutes, and so on.

EFFECT OF VARYING TONNAGE IN TUBE-MILLS

Tons feed 24 hours......	67	80	109	217	239	570	693
Per cent minus 200-mesh in discharge	30.03	30.15	20.04	16.56	16.00	10.28	8.09
Relative time pulp is in tube-mill	119	100	73	37	33	14	12
Tons minus 200-mesh in discharge	20.12	24.10	21.84	35.93	38.24	58.59	56.06

The time element as given above shows very distinctly why the "per cent minus 200-mesh in discharge" appears unfavorable with the large gross feed. The time a particle is exposed to grinding during one passage is but 14 minutes if it is part of the 570-ton feed, as against 100 minutes in the case of the 80-ton feed. With the large feed the particle may pass through the circuit a number of times if necessary, but many other particles may be reduced to the desired size in the first passage, after which they are immediately removed. Why keep such particles within the mill for 100 minutes when 14 minutes will suffice? Better exert the energy on other particles which are still too large. The closed circuit accomplishes this automatically.

The addition to table II merely serves to emphasize and explain what can be seen by inspection of the table as it appears in Mr. Haynes' discussion. I refer to the percentage of initial feed reduced to minus 200-mesh. Under 109 tons we find 21.84 tons, and under 570 tons we find 58.59 tons. That is, we have increased the feed five times to increase the finished product three times. But this does not necessarily indicate bad practice. On the contrary, inspection of the figures shows that to get 58.59 tons of finished product direct from 109 tons of feed about three tube mills would be necessary. From 109 tons, 21.84 tons were finished. This leaves 87 tons. From 80 tons (second column of the table) 24.10 tons were finished. This leaves 56 tons oversize and 46 tons finished, so that we would need a third tube-mill.

There can be no question as to which is the better result. A tube-mill consumes the same power regardless of how rapidly the pulp passes through it, and power is the large item in the cost of tube-milling. As in everything else, there is a point beyond which it is not economical to go in increasing the return feed, as wear and tear of classifier, cost of elevating the return, etc., come into play; but I do not think these factors set the limit in the case under consideration, but rather the direct flow of sands through the tube without being subjected to grinding.

What Mr. Haynes bases his arguments upon are conditions in which the tube-mill is overloaded, and in such cases considerable plus 200-mesh must overflow the classifier weir. These conditions are undoubtedly too common. In fact, he says at the end of his article: "Absolutely the only way to obtain a larger percentage of minus 200-mesh material in the final product is to increase tube-mill capacity," and in this I am in accord with him; but the increase can be brought about with fewer tube-mills if operated in closed circuit than if in series. In a large installation the series arrangement may occasionally work out to advantage by reason of the ability to suit the grinding conditions to the particular feed, which will differ in the second mill from the first; but Mr. Haynes' own figures show conclusively the superiority of the closed circuit, although he attempts to prove the opposite by them.

I believe the closed circuit in tube-milling is with us to stay, just as it is in roll-crushing, and that Mr. Cunningham's formula will be found useful by many operators.

H. B. LOWDEN.

Denver, Colo.

* * *

To the Editor of Metallurgical & Chemical Engineering:

Sir:—I have read Mr. Justin H. Haynes' article in your issue of January 5, entitled Tube-Milling Tonnage Calculation and Notes on Tube-Milling, also Mr. Noel Cunningham's article on Calculation of Returned Feed to Tube Mills.

Mr. Haynes advocates tube mill capacity sufficient to grind the entire feed to desired fineness in one passage through the tube, claiming that the closed circuit is a mistake with no advantages. This does not seem to figure out from his own table, No. 2 on page 11, which contains the data given in Table I.

TABLE I—EFFECT OF VARYING TONNAGE IN TUBE MILLS

Tons feed 24 hrs.	67	80	109	217	239	570	693
%—200 mesh in discharge	30.03	30.15	20.04	16.56	16.00	10.28	8.09
Tons—200 mesh in discharge	20.12	24.10	21.84	35.93	38.24	58.59	56.06

In accordance with this table it would seem that with 67 tons initial feed and the once-through process we would expect 20.12 tons, or 30 per cent, to pass 200 mesh; while should we run the mill on a closed-circuit basis, with 67 tons initial feed, in accordance with the table, when the return has built up to 570 tons we would have 67 tons overflowing the Dorr—58.59 tons of which would pass 200 mesh, or an overflow of which 87.15 per cent would pass 200 mesh.

Mr. Haynes states that it is no exception for a tube mill run in closed circuit to have a total feed of 7 times the initial feed. I feel that this condition is greatly exaggerated, Mr. Cunningham's deductions being much nearer the true condition.

Until a short time ago we had figured tube mill total feed, from screen analysis, about as Mr. Cunningham describes, afterward changing to calculation from plus 28 mesh material showing in feed from batteries which

Table III

Mesh	Battery Discharge Tonnage by Weighed Sample			Battery Tube Feed Tons by Weighed Sample			Battery Dorr Overflow Tonnage by Difference between Battery Discharge and Battery Tube Feed			Tube Mill Discharge Tonnage by Battery Feed and Return Feed			Return Feed Weighed Feed			Return Dorr Overflow Tonnage Battery Feed to Tube			Dorr Overflow General Battery Discharge Tonnage		
	%	% Cumulative	Tons	%	% C.	Tons	%	% C.	Tons	%	% C.	Tons	%	% C.	Tons	%	% C.	Tons	%	% C.	Tons
10	8.2	8.2	6.02	8.2	8.2	5.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14	12.3	20.5	9.03	13.1	21.3	8.80	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
20	11.8	32.3	8.66	12.2	33.5	8.19	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
28	12.2	44.5	8.95	13.1	46.6	8.80	.....	.....	.....	.25	.25	.32	.42	.42	.25	.....	.....	.....	.....	.....	.....
35	8.9	53.4	6.53	9.8	56.4	6.58	.....	.....	.....	.75	1.00	.96	1.41	1.83	.85	.....	.....	.....	.....	.....	.....
48	7.9	61.3	5.79	9.1	65.5	6.12	.....	.....	.....	3.125	4.125	3.98	6.08	7.91	3.66	.....	.....	.....	.....	.....	.....
65	5.1	66.4	3.74	7.0	72.5	4.70	tr	.....	.....	7.875	12.00	10.03	13.17	21.08	7.93	.....	.....	.....	.....	.....	.....
100	5.0	71.4	3.67	10.0	82.5	6.72	2.5	2.5	.155	21.625	53.625	27.55	34.75	55.83	20.90	1.375	1.375	.92	1.375	1.375	1.01
150	4.4	75.8	3.23	10.5	93.0	7.05	9.125	11.625	.565	26.25	59.875	33.42	30.58	86.41	18.40	13.75	15.125	9.24	11.25	12.625	8.26
200	2.2	78.0	1.61	2.2	95.2	1.48	6.0	17.625	.372	8.5	68.375	10.83	5.42	91.83	3.26	10.625	25.75	7.14	7.875	20.5	5.78
−200	22.0	100.0	16.15	4.8	100.0	3.23	82.375	100.0	5.108	31.625	100.00	40.29	8.17	100.00	4.92	74.25	100.00	49.9	79.5	100.00	58.35
Total Tons			73.37			67.18			6.2			127.38			60.21			67.2			73.4

does not show in tube mill discharge, as shown from the screen analysis and deductions in Table II.

TABLE II

Mesh	Battery discharge %	Cumulative %	Tube mill feed %	Tube mill feed % C.	Tube mill discharge %	Tube mill discharge % C.	Dorr overflow %	Dorr overflow % C.
10	10.3	10.3	5.4	5.4	...	...	...	...
14	10.0	20.3	5.2	10.6	...	...	...	...
20	10.2	30.5	5.3	15.9	...	...	...	...
28	11.3	41.8	5.9	21.8	...	...	...	...
35	7.7	49.5	4.9	26.7	1.0	1.0	...	...
48	7.1	56.6	6.5	33.2	3.1	4.1	...	...
65	5.6	62.2	8.1	41.3	6.5	10.6	...	...
100	6.0	68.2	20.0	61.3	20.0	30.6	1.0	1.0
150	6.6	74.8	24.4	85.7	28.6	59.2	12.5	13.5
200	4.0	78.8	7.8	93.5	12.7	71.9	14.2	27.7
—200	21.2	100.0	6.5	100.0	28.1	100.0	72.3	100.0

Tons crushed per day 500. Feed per mill 62.5 tons.

DEDUCTION FROM COARSE MATERIAL

In the battery discharge there was 41.8 per cent, or 26.12 tons, which did not show in tube mill discharge. This material was represented in total tube mill feed by 21.8 per cent. As we know this 21.8 per cent is represented by 26.12 tons, the 100 per cent feed should amount to 119.8 tons.

Total feed	119.8 tons
Initial feed	62.5 "
Return feed	57.3 "
Ratio of return..............	0.92 to 1 ton

DEDUCTIONS FROM SAME BY CUNNINGHAM'S FORMULA

$$a = 21.2$$
$$b = 6.5$$
$$c = 28.1$$
$$d = 72.3$$
$$B = 62.5$$
$$T = X$$

$$\frac{T}{B} = \frac{d-a}{c-b} \text{ or } \frac{X}{62.5} = \frac{51.1}{21.6} \text{ or}$$

T = 146.8 tons total feed
62.5 initial feed
84.3 return feed
Ratio of return 1.35 to 1.

Not being entirely satisfied with deductions from screen analysis, a vertical baffle was made to divide a Dorr duplex classifier into two separate sides, or machines, running feed from the battery to one side and the tube mill discharge to the other side, taking from the discharge from both sides over a given time samples for tonnage by weight and screen analysis. Table III gives the results:

From the tabulated deductions we have:

Tons total feed................	127.38
Tons initial feed...............	67.18
Tons returned feed............	60.20
Ratio of return................	0.91 to 1

I think the error in Mr. Cunningham's method is due to disregarding the coarser than 200 mesh material, which does overflow as finished product.

While I feel that tube mills in series have advantages, it is hard to accept Mr. Haynes' assertion that no advantage is had by mills working in closed circuit over the once-through method when mills are in parallel.

I would like to say in closing that the method of figuring tube mill return from the known tonnage in battery discharge, not showing in tube mill discharge which checks out very close to the actual figures from weighed samples, originated with Mr. F. C. Reynolds, who has charge of our experimental work.

A. H. Jones,
Mill Superintendent.

Belmont Milling Company,
Tonopah, Nevada

The Iron and Steel Market

At the end of January the steel industry finds itself in no better position than at the begining, but the improvement that occurred during December has been maintained. The course of the market in January admittedly has furnished disappointment, not only because hopes were entertained, but also because expectations had been entertained that after the early days of January the December improvement would be continued.

The steel mills have operated during January at an average rate of fully 45 per cent of capacity, against an average of not more than 35 per cent during November and December. The current orders are of a miscellaneous character, there being no marked demand in any direction. There does not seem to be any replenishment of stocks in the hands of jobbers or manufacturing consumers. Such stocks had been subject to successive reductions, the last being occasioned by the tightness of money late in the old year, so that consumption was doubtless in excess of production in November and December while now consumption is at the same rate but production is somewhat heavier.

During the last five months of 1914 there was practically no buying by railroads. In the past month there has been an improvement, but viewed at long range the railroad buying is still very light.

Export demand is running quite largely to war material, both in the regular products of the steel industry and in the manufactured goods of its customers. The steel industry's exports are at record rate in barb wire, for instance, although the normal demand for barb wire from neutral countries has greatly decreased. Exports of lathes, motor cars and other things involved in war or the manufacture of implements of war are heavy. The latest export statistics are for November, showing 141,000 gross tons of iron and steel against 147,000 tons in October and an average of 141,000 tons a month during the first seven months of 1914.

It is clear that the steel market has not, thus far at least, responded as might naturally be expected to the great improvement in fundamental conditions, the heavy

export demand resulting during January in an enormous favorable merchandise trade balance, and the failure of foreign holders of American securities to dump them in our market, the result of these factors being a decline in exchange on London to below par while money for ordinary commercial purposes has become easy. In the circumstances the steel trade should be more prosperous than it is. There are hopes that the market will gradually broaden but there are no concrete developments in the steel market itself sufficient to support a a theory that it will.

A very sharp advance in spelter prices towards the close of the month created great excitement in the galvanized sheet trade, and prices advanced sharply, some mills, indeed, withdrawing from the market entirely until more settled conditions should develop in the spelter market. At the middle of October spelter sold at but a shade above 4½ cents, East St. Louis. At the end of the year it stood at 5½ cents, but in the week beginning January 18 it advanced from 6 cents to about 7 cents. A change of one cent a pound in the cost of spelter is commonly computed to mean a change of $3 per net ton in the cost of making galvanized sheets.

Pig Iron

The pig iron market has been quiet the past month, but prices have been well maintained. A general though somewhat restricted buying movement had occurred in northern iron late in the old year and the northern furnaces are in at least as good position as a month or two ago. The southern situation is anomalous. There was no general buying movement in southern iron, such as has always accompanied or even preceded a movement in northern iron. At the same time only two or three southern producers are free sellers, others holding to quotations that cannot let them into the market. Production has shown no distinct tendency to increase or decrease. The market is quotable as follows: No. 2 foundry, Birmingham, $9.50; delivered Philadelphia, $14.45 to $14.95; f.o.b. furnace, Buffalo, $13; delivered Cleveland, $13.25; f.o.b. furnace, Chicago, $13; at valley furnaces (95 cents higher delivered Pittsburgh) Bessemer, $13.75; basic, $12.50; Nor. 2 foundry and malleable, $12.75 to $13.25. Ferromanganese on contract is nominal at $68, Baltimore, contracts being subject to embargo provisions that have not been thoroughly worked out. Prompt lots can usually be picked up at $75 to $80.

Steel

After covering nearly all consumers of billets and sheet bars for longer or shorter periods, usually the first quarter of the year, at low prices, averaging about $18.50 for billets and $19 for sheet bars at maker's mill the mills began to advance prices in January, Pittsburgh mills to $20 for billets and $20.50 for sheet bars and Youngstown mills by smaller amounts. Rods have stiffened to $25, Pittsburgh and some mills will not meet this quotation.

Finished Steel

Current quotations are as follows for ordinary deliveries, quotations being f.o.b. Pittsburgh unless otherwise noted.

Rails, standard sections, 1.25c. for Bessemer, 1.34c. for open-hearth, f.o.b. mill, except Colorado.

Plates, tank quality, 1.10c.

Shapes, 1.10c.

Steel bars and bands, 1.10c., base; hoops, 1.20c. to 1.25c.

Refined iron bars, Pittsburgh, 1.15c.; common iron bars, 1.12½c., Philadelphia; .97½c., Chicago.

Sheets, blue annealed, 10 gage, 1.30c.; black, 28 gage, 1.80c.; galvanized, 28 gage (uncertain), 2.90c.; painted corrugated, 28 gage, 2.00c.; galvanized corrugated, 28 gage, 2.95c.

Tin plate, nominal price, $3.20 for 100-pound cokes; large lots at $3.10 or possibly less.

Steel pipe, ¾ to 3-in., 81 per cent off list.

Steel boiler tubes, 3½ to 4½-in., 74 per cent off list.

Standard railroad spikes, 1.35c., Pittsburgh; 1.45c., Chicago.

Cold rolled shafting, 68 per cent off list.

Structural rivets, 1.35c.; boiler rivets, 1.45c.

Chain, ⅜-in., proof coil, 3.00c.

The Western Metallurgical Field

Spelter

The apparent steady improvement in the spelter market, as reflected by the upward trend of prices to six cents at St. Louis, is stimulating activity among producers of that metal. The outlook is regarded as very promising, and seven-cent spelter is freely predicted as a possibility before the close of the year. With the improvement in conditions, large producers are resuming operations. Butte & Superior is again operating its concentrating plant at Butte, and the new Timber Butte mill which treats ore from Senator Clark's Elm Orlu mine is also handling a large tonnage. The Granby company has begun smelting Joplin high-grade zinc ores at its new smelting plant at Roselake, Ill. This new smelter is situated near the coal fields of Illinois, in accordance with the tendency of building new smelters out of the natural gas districts of Kansas and Oklahoma. The furnaces are heated by producer gas, and the plant includes a sulphuric acid department.

The tentative proposal to erect on the Atlantic seaboard of this country a zinc smelter to reduce Australian concentrates which have been treated in Germany, received a set-back by the decision that the war does not abrogate the contract existing between the Zinc Corporation and Aaron Hirsch & Son. Australian producers have been placed in an awkward position by the fact that German smelters hold contracts for reducing the tremendous output of Australian concentrates. Apparently this precludes the possibility of smelting this material in the United States, or for that matter in England. The treatment of the Australian output in this country would be desirable from an economic point of view, as it would affect the whole industry in a manner favorable for the United States, but such an outcome does not appear possible now.

Joplin producers of zinc concentrates have been stirred recently by the belief that St. Louis quotations on spelter are not reliable and do not represent the true condition of the market. It is claimed that the quotations indicate prices for low-grade spelter, while the product of Joplin ore is of higher grade, commanding a higher price. As a consequence of these conditions, it is felt that Joplin producers do not get a price for their product commensurate with its grade. The Joplin Commercial club has been asked to attempt to rectify this matter by requesting the Merchants' Exchange of St. Louis to "adopt rules regulating the transactions in spelter which will make it possible for the exchange to stand back of and guarantee such quotations." At present the St. Louis quotations emanate from the Merchants' Exchange, but that body cannot guarantee their accuracy as it does on other commodities.

Consumption of Cyanide in Oregon

Supplementing the figures of the U. S. Geological Survey on cyanide consumption in the United States, given on page 743 of our December issue, we have secured from Oregon operators figures indicating an annual consumption in that state of 104,000 pounds. It

is expected that a new operator will commence work this year and augment the consumption by a small quantity. With the exception of California, the figures given in our December issue and herewith afford a complete statement of cyanide consumption in the gold and silver industries.

Alunite in Utah

Mention has been made previously in these columns of the existence of alunite deposits near Marysvale, Utah, which are potential sources of potash and aluminum. From recent reports emanating from Marysvale, it appears that the development and test of these deposits may be undertaken in the near future. It is reported that a contract has been let for the mining and transportation of 350 tons of this alunite to an eastern point, where experimental work will be done. In the event of a successful method of extraction being developed, a commercial plant will be established in Utah. The Florence Mining Co. is the concern doing this preliminary work.

Copper Leaching and Flotation Processes

Activity in developing and operating copper leaching processes for oxidized ore continues in a marked degree at several western points. At the same time flotation processes are being rapidly developed, and may have a decided effect on the future of leaching. In our last issue, page 63, we noted a patent granted to Mr. Joseph T. Terry, Jr., of San Francisco, California, for the flotation of oxidized ores of copper and other metals, by previous conversion of carbonate or oxide forms into sulphides by means of hydrogen sulphide, and then recovering the mineral by flotation as in the case of original sulphides. This method of "sulphide filming" and mechanical recovery may be found more advantageous from an economic point of view than that of leaching. At least it appears simpler to grind, convert and float ore containing oxidized copper mineral, than it does to handle the same ore by a hydrometallurgical process, with its large volume of circulating solution, incomplete extraction, economic limit of washing out dissolved metal, difficulties of precipitation, fouling of solutions, etc.

The sulphide-filming process admittedly gives a low-grade concentrate, due to the fact that the reaction between the oxidized copper compounds and hydrogen sulphide is so strong that particles of gangue containing even a minute quantity of copper will become converted to sulphide and thus float with the concentrate. It is understood, however, that further improvements in the application of sulphide-filming give promise of affording a method of producing a high-grade concentrate with practically complete extraction. Just what the final effect of this type of process will have on the future of leaching is difficult to forecast, but there is a possibility that progress in leaching may halt to determine the advantages of the new idea.

Chemical Control of Copper Leaching

A number of important analytical operations are involved in the control of copper leaching processes. Some of these are not exact, but give concordant results and afford quick determination to control mill operation. If the same methods are used on a variety of ores, comparative results can be obtained that will be valuable for reference. A solubility test can be made by treating 1 or 2 grams of ore in a beaker with 20 cc. of 5 per cent sulphuric acid (5 deg. Be., or 1.035 sp. gr.), allowing the mixture to stand for about 24 hours. The dissolved copper is filtered and washed from the residue, and determined by electrolysis.

The determination of free acid in the mill lixivium can be made by titrating in the cold a 50 cc. sample with standard sodium carbonate solution (1 cc. = 50 mg. H_2SO_4). The end point may be observed by the use of methyl orange, or the titration can be conducted without an indicator until a slight permanent precipitate appears after shaking. The presence of much manganese will vitiate the results, but with ordinarily clean solutions either method is satisfactory. If extreme accuracy is desired, the solution can be evaporated to dryness on a water bath. The residue is treated with absolute alcohol, filtered and titrated.

Iron will exist in both states of oxidation. Ferric iron is obtained indirectly by difference between total and ferrous iron. To determine ferrous iron, dilute say, 50 cc. of the liquor to about 200 cc., add 10 cc. sulphuric acid and titrate with standard potassium permanganate solution (1 cc. = 10 mg. iron). For total iron, dilute 25 cc. to about 100 cc., add sulphuric acid as before and boil with metallic zinc to precipitate copper and reduce all iron. Complete reduction can be determined by testing with KCNS. Cool and titrate as before, determining total iron. Copper in the mill solution is determined by electrolysis, and from the remaining solution the determinations for manganese, magnesium and lime can be made.

Company Reports

The ninth annual report of the *Consolidated Mining and Smelting Company of Canada, Ltd.*, for the year ended September 30, 1914, shows net profit from operations of $474,012, out of which four dividends aggregating eight per cent, or $464,376, were paid. The properties of the company are reported in good condition. The sum of $482,134 was spent on improvements at the smelter, comprising two Wedge roasters, conveyors and automatic scales for handling material in connection with the roasting plant, three new lead blast furnaces, Cottrell plant for precipitating fume from blast furnace gas, rebuilding three copper blast furnaces, installation of an additional blower having a capacity of 40,000 ft. of air per minute, rebuilding fire protection system, etc.

The additions to the roasting plant were necessitated by changes in the ore supply, demanding more capacity. The Godfrey roasters already in use had a capacity of only 25 tons each per day of Sullivan ore, whereas the two Wedge roasters recently installed have a capacity of from 85 to 95 tons each per day, and cost about 50 cents less per ton to operate, the saving being mainly in fuel. The cost of operating the Huntington-Heberlein pots has been reduced by the introduction of mechanical appliances for hand labor. The addition of a Cottrell precipitating plant was necessitated by losses in blast furnace gases. Since completing this installation, about eight tons per day of lead product is being saved. The rebuilding of furnaces was made necessary by the deterioration of the old ones. Two of the copper furnaces have been enlarged from 300 in. to 420 in. in length, and from 42 in. to 50 in. in width at the tuyeres. The enlarged furnaces show an increase in smelting capacity of from 60 per cent to 80 per cent over the old ones. The changes made at the smelter during the past two years will result in sufficient saving in cost of operation and recovery to pay for themselves within the next two or three years.

The Electric Furnace Products Co., Ltd., of Saude, Norway, has been organized for the production of carbide and other electro-metallurgical products. The probable production is estimated at 60,000 to 80,000 tons annually, to be exported to the United States.

The Non-Ferrous Metal Market

There has been a distinct improvement in the non-ferrous metal market during the last thirty days. Copper and spelter especially have been very strong. Lead is inclined to be weak, with tin about stationary. The advance in prices has been substantial and it is felt that the improvement is warranted and will be maintained.

Copper.—Both domestic and export business has been good and prices seem to be firmly established. Prices have ranged as high as 13¾ cents, and a large business has been transacted at 13½ cents, New York.

Tin.—This market has recovered from a decline in the London market and prices are firm again at about 33¾ cents for January tin.

Lead.—Prices for this metal have fallen due to close competition between independent interests and the largest producer. The American Smelting & Refining Co. finally reduced the price to 3.70, which is the latest available figure. St. Louis market is quoted at 3.50@3.55.

Spelter.—Consumers have been buying heavily and steadily, and the large volume of business has resulted in advancing prices. Export business continues good in high-grade spelters, these brands commanding a premium. The New York price for ordinary grades is 6.02½@6.07½ cents, with St. Louis at 5.85@5.90.

Other Metals.—The aluminium market is quiet, with prices firm at 19@19¼ cents per lb., New York. Antimony is showing more firmness as stocks decrease, and prices for ordinary brands have raised to 14½@15½ cents, with Cookson's at 16½@17 cents. The New York quotation for quicksilver is $50 per flask of 75 lb.; the San Fracisco price is $49.

The Presentation of the John Fritz Medal to John Edson Sweet

On December 2, 1914, the auditorium of the United Engineering Society Building was filled to overflowing with a representative gathering of engineers and their ladies to see the presentation of the "John Fritz Medal" to John Edson Sweet, founder and president of the Straight Line Engine Company, professor of mechanic arts at Cornell University in its early days, the virtual founder of the American Society of Mechanical Engineers, of which he is a past-president and honorary member, and recipient of the degree of Doctor of Engineering from Syracuse University.

Gano Dunn, past-president of the American Institute of Electrical Engineers, presided and was supported on the stage by the members of the board embracing many of the most distinguished engineers in the country.

The manner of Mr. Dunn's presiding was so admirable as to call forth almost universal comment. He said all that was necessary without arrogating to himself the opportunity to make a speech; while his enunciation without being slow and therefore tiresome, was so clear-cut and distinct that every word must have been audible in the farthest reaches of the auditorium.

Dr. James Douglas, past-president of the American Institute of Mining Engineers, made a brief but suggestive address upon the ancient partnership between the miner and engineer, the former being first the dominant partner. He described how through the evolution of his manifold activities the engineer had first reached, and then passed in importance all his competitors in mining and industrial life, but Dr. Douglas pointed out that great as the engineer had become he would never be able to dispense with the miner, on whom he must depend for the materials upon which to practice his art.

Dr. Douglas was succeeded by Dr. W. S. Stratton, director of the United States Bureau of Standards at Washington, whose address consisted largely of a catalog and explanation of the activities of his bureau.

He was followed by Mr. John R. Freeman, past-president of the American Society of Mechanical Engineers, who told the story of the establishment of the "John Fritz Medal," the method of its award, and outlined the notable achievements of Professor Sweet in furthering the mechanic arts, in teaching sane and rational principles of design, and in applying what had been until then only curiosities in the way of scientific measuring instruments, to the construction of commercial machines, with the result of building machinery of a quality of which America at least up to that time was ignorant.

It was a clear, concise statement of facts without direct praise to the recipient, such as every engineer should be, and unfortunately only a few are, able to make.

It may properly be stated here that Professor Sweet has done surely as much, and perhaps more to introduce accurate methods of measurement into industrial life than any other man in America, having designed and made among the very earliest of the straight edges, surface plates, accurate squares, and michrometer calipers ever made in this country.

When he founded the Straight Line Engine Company some thirty years ago he applied these instruments and many others specially designed for the purpose, to the construction of his engine and put it on a plane of workmanship far beyond that of any other engine builder and equal to, if not beyond, the standard of the most accurate machine tools. This workmanship, combined with boldly original designing, resulted in putting his engine in a class by itself.

He did not try to maintain his lead by closing his shop to others and preventing them from following his methods; but, on the contrary, carved in the stone arch over the entrance door, there were the words "VISITORS ALWAYS WELCOME," which he made literally true, and in addition he licensed his rivals to use patented features of his design.

This shortened the period of his engine's pre-eminence but vastly improved the standard of high-speed engine building. Not only has he always offered priceless information freely, he has been blessed with the gift of teaching in its broadest sense, such as few men possess; the gift of putting into simple language the most difficult explanations and in such original and striking form that the hearer can not only understand but can scarcely forget them.

The writer can remember after the lapse of more than twenty years almost the exact language used in making many explanations of difficult points. This is true not only of technical affairs; in matters of ethics an instinctive knowledge of the right has many times within the writer's knowledge, found expression in simple language which seemed to put any but right conduct beyond consideration.

It has sometimes happened, though perhaps not very frequently, that a man had made wonderful achievements as an engineer, but in the minds of those who knew him best had spoiled it all by undue pride in his own accomplishments, denying others just recognition for their help or other defects of character impossible to forget in connection with the man, but this is not such a case. Professor Sweet is less widely known than he might well be in virtue of his great achievements because of his excessive modesty. It is probable that of all the hundreds there gathered John Edson Sweet was the only one who did not think that he deserved the "John Fritz Medal."

On his personal side Professor Sweet has always had a gift pertaining only to character, and never to achievements alone, of attracting to himself, from his earliest years down to the present time, those with whom he had been thrown in contact, and maintaining relations in many cases of positive affection with them, not for short periods, but for life.

It is probably not known to more than a few people that instead of the occasional birthday dinner which has been given to some distinguished men, Professor Sweet has been the recipient of this honor annually for every year except one for the past fourteen years, the one exception being a year when he was out of the country at the time for this annual gathering.

The dinner has been a small one made up of those whom Professor Sweet himself had spoken of as his "boys"; though most of them are now gray and many of them white-haired. The first of these dinners was held in 1901 in response to a suggestion from one of the "boys" that it would probably be a matter of great gratification to "Professor," as he is universally called, to see as many of the "boys" as possible gathered together at one time, his association with them having been scatered over a wide range of time and space, so that while each individual knew the names of many of the others he knew but few of them in person. The plan was carried out in complete secrecy as regards "Professor" at the annual meeting of the American Society of Mechanical Engineers in New York in 1901, since this followed by only a few weeks Professor Sweet's seventieth birthday, and was the easiest occasion on which to get together a large percentage of the "boys."

At the first dinner about forty out of a total of sixty who had been reached were assembled, and the memory of the delight with which "Professor" saw what had been for many years the dream of his life carried out, the foregathering of a large percentage of the "boys" at one time and place, will never leave those who had the privilege of seeing it.

The occasion was made the opportunity for the presentation of a watch with magnificent works, but a case of "Bower-Barffed" iron, suited to the quiet taste of the recipient, and embellished with a tiny bas-relief of the first Straight Line Engine.

This first gathering was so great a success in all particulars that it was voted to make it an annual affair, a plan which has been carried out ever since.

These are perhaps not matters of technical importance but they may help to give to those who do not know in person this year's recipient of the "John Fritz Medal" an idea of his character such as direct description alone could not do. It is doubtful if the receipt of the medal by any other American engineer would have given pleasure and satisfaction to so great a number as has this award.

J. E. J., Jr.

A pyrophoric alloy patented by Anton Kratky contains 84 per cent rare earth or cerium, 8 per cent magnesium and 8 per cent zinc or its equivalent in cadmium. The alloy is said to be very suitable for lighting devices working on the strike principle.

The production of nitrate in Chile has been seriously affected by the war, and thousands of people have been forced into idleness. The problem of caring for the unemployed has seriously come up.

Transvaal Gold Production.—The number of companies reporting to the Transvaal Chamber of Mines in October, 1914, was 60. The total quantity of ore milled during that period was 2,357,695 tons. There were 9854 stamps in operation with an average duty of 8.96 tons per 24 hours. Tube mills in commission numbered 294. The yield for the month was 733,746 fine ounces gold, the largest for the year.

Hearing of the Proposed Amendment of the Patent Laws

On October 8, 1914, Congressman Calvin D. Paige of Massachusetts introduced a bill in Congress (H. R. 19187), proposing an important change in the patent laws in especially two directions, namely, first, that a patent shall be granted only for the *process* of making a drug, medicine, or dyestuffs, and not upon the *product* itself; and, second, that any patent relating to the manufacture of drugs, medicine, or dyes, shall be actually worked in the United States within two years.

A hearing was held on January 13 and 14, 1915, before the Committee on Patents of the House of Representatives, Chairman William A. Oldfield presiding.

Congressman Paige made the opening statement in which he explained that he had introduced his bill for the relief of the textile industry of this country, the intention being to alleviate the dyestuff situation created by the European war and break the world-wide monopoly of Germany in dyestuffs. The bill is not intended to apply to all patents, but simply to the dyestuff industry.

A general discussion followed in which Congressman Herman A. Metz of New York was most prominent in opposing the bill. He denied that the finishing companies and woolen manufacturers were not adequately supplied with dyestuffs. "The dyestuffs are coming in in adequate quantities, and will continue to come in in larger quantities." The prices of dyestuffs to American consumers are higher by 25 per cent than before the war, but only 10 per cent is due to an increase in price of the manufacturer and 15 per cent to the increase in freight rates and insurance rates.

Mr. Metz denied that the compulsory working clause, after it had been introduced in England, had worked satisfactorily. Mr. Metz also emphasized that the Committe on Chemicals and Dyestuffs of the New York section of the American Chemical Society had expressed itself unanimously against a compulsory working clause (see this journal, Vol. XII. p. 754).

Mr. Metz emphasized that "a plant does not make dyestuffs; a patent does not make dyestuffs; it is the material necessary to make them with. Those materials we have not got here, and we will not have them for some years to come. It is an interlocking proposition. . . . The question of patents we have had for years. Manufacturing it is really a question of tariff. There are 900 articles free, and there are only about 5 per cent of articles that are patented."

Mr. Georgii pointed out that the essential features of the manufacture of dyes in Germany are not so much based on patents as on trade secrets.

Mr. William G. Garcelon, attorney at law and secretary of the Arkwright Club of Boston, made a statement in which he said that the difficulty of the New England mills "perhaps goes deeper than the dyestuffs question, because the mills cannot sell their goods." They have bought a year's supply of cotton at somewhere between 13 and 15 cents, and now, when the price has dropped to 6 and 7 cents, the mills find themselves stocked with high-priced cotton and the buyers demanding goods on the basis of 6-cent cotton.

Mr. Garcelon would not now express himself definitely one way or the other as to the desirability of the legislation in question, though he discussed several points. "I am frank to say that I can go to certain men in Massachusetts today who have not discussed this question and I could get them to say, 'Yes, it is a fine thing; put it through; it looks good to me.' On the other hand, I am frank to say, I can spend an hour with them and present some of these things and they would say 'It is a bad thing; do not put it through'!"

Mr. JOHN H. BRICKENSTEIN, of the firm of Byrnes, Townsend and Brickenstein, patent attorneys, of Washington, D. C., emphasized that "this bill is making a fundamental attack on the general principle of the whole law under which patents are granted. It is not only an attack on that principle but it is for the benefit of a certain few, and is class legislation of the rankest kind." Against the proposition to make the bill general, the objection must be raised that this would deprive a patentee of one of his exclusive rights to his invention. In a rather amusing colloquy with Congressman Oscar Callaway of Texas, Mr. Brickenstein went to some lengths to explain that patents are granted in order to induce an inventor to disclose his invention.

"An inventor has got something worth while, and he will not disclose it, and Congress says to him, 'If you will disclose it we will protect you for 17 years,' and that is the inducement for the disclosure, and it has been that disclosure and the patents granted that have enabled the inventor to make money out of his invention, which has so enormously stimulated the manufacturing industry in this country."

Mr. Brickenstein argued that the bill would be in direct opposition to the existing treaty with Germany; further, in proposing to grant patents only on processes, not on products, "we will take away from the chemical manufacturer the most valuable kind of patent he can get. . . . Chemical process patents, as our courts are now constituted, are enormously difficult to sustain. The passage of this bill, with the elimination of product patents, would practically in this country take away every stimulus to the disclosure, which is the thing the law is after, the disclosure of any chemical inventions that are made. Everybody who could would keep them secret."

Mr. Brickenstein quoted from *Metallurgical and Chemical Engineering* (September, 1914) Dr. Hesse's exposition of the economic reasons why not more dyestuffs are made in this country. He emphasized that the way to begin a dyestuff industry is with the coke ovens.

A letter by Dr. BERNHARD C. HESSE, chemical expert of New York, to Mr. Metz was read in which he expressed the opinion that "there is no reason to believe that any good whatever will come from H. R. 19187 were it to be placed bodily on our statute books; on the contrary, all past experience allows of but one conclusion—namely, that H. R. 19187, if enacted into statute, would raise false hopes, and a false sense of security, and would miss fire absolutely."

DR. BAEKELAND'S STATEMENT

The most extensive statement of the hearings was made in the session of January 14 by Dr. L. H. BAEKELAND, of Yonkers, N. Y., president of the Inventors' Guild, past president of the American Electrochemical Society, the American Institute of Chemical Engineers, and The Chemists' Club. "The Paige bill aims at some evils which are supposed to exist in our patent system and which relate to the manufacture of chemicals. It would be useless to deny that certain of those evils exist. We know that certain foreigners take out chemical patents in the United States, not with the idea of working them but with the idea of preventing others from carrying out those patented processes. But such occurrences are relatively rare, and on account of this I think it is wrong to exaggerate any statements as to the extent of that evil.

"The Paige bill aims at suppressing the possibility of taking out a chemical patent without working it. The question is: Are the means proposed by the Paige bill the correct ones, and in suppressing the evil will the remedy not be worse than the evil itself?"

COMPULSORY WORKING CLAUSE

Dr. Baekeland first took up the proposal of the compulsory working of patents and recited how similar clauses have worked in other countries. He first spoke of Belgium. "Belgium has a patent law which provides compulsory working of patents. Belgium has, furthermore, a patent law which forbids the taking out of a patent for medicinal preparations."

"At the same time, Belgium can not boast of a chemical industry similar to that of Germany, neither in importance nor in variety, yet it would be very easy in Belguim to manufacture a large number of chemical products which are now made in Germany. I do not need to dwell on the spirit of industrial enterprise of Belgium. Belgium is a very highly organized industrial country, and in several industries outclasses the Germans—for instance, spinning and weaving industries, some metallurgical industries. But, what is more interesting, Belgium is the very country from which Germany gets the raw materials for the manufacture of aniline dyes.

"There is one detail which many of you probably have overlooked; that is, that when you speak about coal tar, which is the base of the aniline dye industry, any coal tar is not good for that purpose; it needs special coal tars, and it so happens that German coal tar is not so good, while Belgium coal tar is very good; English coal tar is good, too, and yet Belgium prefers to send its valuable coal tar to Germany and let the Germans fuss with it and produce many chemicals from it, which are exported and distributed the whole world over, and the Belgians buy back some of those dyes and chemicals manufactured by the Germans by means of the very raw materials sent there from Belgium." (In reply to a question by Mr. Metz, Dr. Baekeland said that the American coal tar is totally unsuitable for the profitable manufacture of some of those chemical products.)

"The Belgians prefer to weave cloth, spin yarns, make tissues, and to dye them with dyes manufactured in Germany. A few dyes are manufactured in Belgium, but the production of those dyes is a small industry; that is, as far as Belgium is concerned.

"In England a similar condition of affairs exists. England had introduced the compulsory working clause in her patent laws and had great expectations, as we always have before we try an experiment. It so happens that as far as the production of dyes is concerned, England is no better off than the United States. In fact, Mr. Metz forgot to mention the important fact to you that certain special coal-tar dyes are manufactured in the United States to a larger extent than in Germany or any other country in the world. It so happens that the manufacture of those particular dyes suits the special conditions of this country."

In answer to the question by the Chairman as to how the introduction of the compulsory working clause had worked in England, Dr. Baekeland spoke of the effect on a chemical process of his own. "I sold my patents in Europe, but on account of the compulsory working law in England we were compelled to start a special smaller factory in England. The market in England was so restricted that we could not to advantage organize the complete technical, scientific and engineering staffs nor the full equipment which is needed for conducting that particular enterprise in a profitable way with a limited market, and in England there has been every year a steady loss, so that we have to write off from the books every year a considerable sum of money. We are not able to produce in England all the different varieties of that particular product, for the reason that we could not possibly keep up a sufficiently large installation, and the result has been that England could not

be as well supplied with the many varieties of the particular product I am referring to. The question is being debated and will probably be decided in the affirmative that we shall be compelled to stop the manufacturing plant in England entirely. We prefer to forego the British market than to be compelled to work at a loss. .

"I know that a similar thing has happened with other manufacturers. After a few years they came to the conclusion that it was cheaper not to take out patents in England after they realized that the market in England was too restricted for a complete and expensive chemical plant and organization. The same kind of logic applies to Canada, where they have also a compulsory working clause, which is further aggravated by the fact that you can not import in that country any goods patented in Canada without losing your patent rights, so that you can not even try the market possibilities before incurring the risk of building a manufacturing establishment. . . .

"The result is that many inventors—and I am one of them—have concluded that it is better not to take out any patents in Canada. Nobody will use your manufacturing process there anyhow; because if some one takes all the risks of starting a manufacturing establishment without patent protection, the next man can do just as much and follow his footsteps without incurring the risk of 'pulling the chestnut out of the fire' in starting an industry on an experimental scale." (In reply to a question on labor cost Dr. Baekeland explained that labor in the chemical industry plays a relatively insignificant part. "Our labor bill is predominantly for high-salaried chemists and engineers, scientific and technical men.")

Dr. Baekeland further pointed out that "in most countries the so-called working clause is an absurd farce. In Belgium and Italy and Spain it is sufficient to advertise in the newspaper that you are trying to give a license or that you are trying to make commercial connections for working your patents: in other countries all that you have to do is once a year to make some kind of a manufacturing operation before witnesses, and have them sign a certified affidavit that certain operations have been gone through as specified, and then you are all right for another year. Of course, that is rather expensive, but rich manufacturers, rich corporations, and rich inventors can afford it; poor inventors can not afford to do it. The result is that you will find that in most of those countries the poor inventors who have barely the means of paying their patent fees are 'frozen out,' while rich patentees are willing to take their chances, and therefore prefer to spend some money, which may look like a large sum of money for a poor inventor, but which for a large establishment is simply charged to general expenses, while they carry out religiously the formalities of the compulsory working clause every year. The result is that this just increases the general expenses of the manufacturing establishment and the consumer pays for it. It is charged under general expenses, like insurance and everything else.

"In England they have tried to be more drastic, and they specify how much of the material shall be produced in England, and by limiting the amount of patented material which can be imported, they stipulate that the patented material has to be manufactured in an adequate or substantial amount in England. It was just on account of this recent change in the patent laws of England, and during the first hesitation which was produced by this amendment to the law, that several American and German manufacturers started building factories in England. But the result has been that in many instances foreign patentees came to the conclusion that their British enterprises did not pay. Now they are willing to take chances, since they realize that after all if anybody takes up a process, of which the patent was allowed to lapse because the operation of that patent was unprofitable, nobody would care to operate it at a loss and they might as well import the product manufactured more profitably in another country."

With respect to Germany and its compulsory working clause Dr. Baekeland said he had made extended inquiries. "Practically without dissent everybody in Germany told me that the compulsory working clause there had proved of no value; and when I asked them, 'Why do you not drop it?' they said, 'for the simple reason that as long as we have this compulsory working clause we can use it as a retaliatory measure, as an act of reciprocity. We can keep it as a "club" over the heads of England, of France, and of all these other countries which are still pressing us with the compulsory working clause, and if you Americans were smarter you would help us do the same thing by introducing a compulsory working clause into your patent laws, with the provision, however, that the citizens of such countries which do not compel Americans to work their patents in their own country would be also exempted from compulsory working of their American patents.' He told me that this was the only reason why they decided to maintain the compulsory working clause in Germany.

"I believe if anybody wants to introduce from that standpoint such a measure in our patent laws as an act of reciprocity he can accomplish considerable good, but in that case this particular bill ought to be worded differently from the Paige bill." (Dr. Baekeland was here asked by the chairman to write out what he considered would do the work.)

THE PROPOSED SUPPRESSION OF PRODUCT PATENTS

As to chemical patents Dr. Baekeland emphasized how little the scope and purpose of chemical patents is understood by people who are not chemists. "In fact, to my great astonishment, I have found more and more that not only ignorant people but so-called educated people do not know what a chemical patent means. They think it is a patent medicine or something of the kind. Few chemical patents, or at least few important chemical patents, relate to pharmaceutical preparations. The scope of chemical patents is far broader, considerably more important from the general standpoint of industrial development and civilization." As examples of chemical inventions of far reaching industrial importance he cited the manufacture of high explosives, the process of making cellulose which gives cheap paper, the manufacture of aluminium, the cyanide process and so on. "Every one of those processes was a purely chemical process. When you begin to seek a difference between chemical and medicinal products, I can not see where to draw the line."

A chemical dyestuff may suddenly become a medicinal preparation. "There is, for instance, a substance which is called phenolphthalein, which is a dye of a red color and because it has such intensive dyeing properties, some wine producers thought it was excellent to use it for giving a peculiar red tint to their wine. They only had to introduce the smallest, infinitesimal amounts in order to obtain that particular red tint; but after they began to sell their wine there was suddenly in the whole district an epidemic of diarrhœa. By sheer accident they had found that the chemical which up until now had only been used for coloring purposes was a most efficient purgative."

"Chemists labor under great difficulties with their chemical patents. If we have a good patent we are continuously exposed to infringers, and the worst thing is most of the time we can not catch the infringers. As I have said, chemical processes require very few workmen. More than one chemical process is operated with

a single man, and often that man can produce 10 tons as easy as he can 10 lb.; in fact, with proper equipment it is much easier to produce 10-ton than 10-lb. lots for the reason that some of these industries can not be worked profitably on a small scale.

"Last year about this time I was spending about four weeks of my sweet life 'suing' one of the infringers of my patents, and the trouble was that it was very difficult, almost impossible, to establish infringement, because that man, who was a rich manufacturer, made the whole preparation himself; he did not allow a single workman to be present. He testified in court to that effect. We wanted to know what the raw materials were which he used. In Germany it would have been easy enough; in France it would have been easy enough; and in England it would have been easy enough, because the court would have appointed a confidential expert, bound to secrecy, to go into his factory and examine what he was using there. But our rules of evidence here in the United States will not allow this. So we had to establish what raw materials he was using, and therefore the judge directed him to bring before the court his books and invoices and the receipts, and the defendant simply said, 'I have no invoices, I have no records as to my purchases, and I burn all my receipted bills,' and there we stuck. This is not an isolated case. I could take up your time by giving you several more similar cases. . . . I am still waiting for the decision. I have waited a year now. The lawsuit cost me many, many times more than any damages I ever might be able to collect.

"Therefore when a chemist takes out a patent he first tries to see whether he can not obtain a product claim; if he can obtain a product claim, then it becomes easier for establishing infringements, and that is so true that the patent pirate will readily find some way to infringe a chemical patent which does not have a product claim. In Germany they allow no product claims for chemicals, but inventors there do not need them. We would be perfectly glad to have product claims suppressed, done away with, if we had a different and more efficient court procedure.

"It is not a question of patent law, it is a question of court procedure, it is a question of rules of court and broad interpretation of the claims of the patent; unless you can give us those improved rules of court procedure —and these are mighty difficult to introduce in the country where our very Constitution starts from another standpoint, where the rules of evidence are based on another kind of logic than that which impregnates the whole German code and the method of administering justice. If you suppress to us, gentlemen, our product claims you might just as well suppress all chemical patents. Our chemical patents do not amount to a large proportion anyhow. As far as I recollect, they only amount to about 1 per cent of all the patents taken out in the United States.

"But if you suppress a product claim in chemical patents why do you not apply the same rule for mechanical patents? Most mechanical patents are practically product claims. Why should you single out chemical patents? If a man infringes a mechanical patent you can easily detect the infringement, you do not need any detectives nor special chemical knowledge. We tried to use detectives once in the case of an infringer. We sent him to the infringer's factory and tried to get a small amount of the raw material to establish the infringement. The value of the material that man took amounted perhaps to 2 cents. He got arrested; he was indicted for larceny and put in jail. In the meantime they keep on infringing my patents. Why? Because when you sue on a process claim you generally can not get at the infringer except in certain cases. You could not break into one of those chemical establishments with dynamite; most of them use secret processes, and that is something which evidently Mr. Paige overlooked when he drafted the bill. I am sure he does not want to harm chemical industries, because his very bill aims at supporting chemical industries. He wants to back them up; he wants to make them stronger in the matter of competition with foreigners. He is perfectly justified in trying to do this, but unfortunately in trying to accomplish that result he is going to do incalculably more harm than the good he is trying to accomplish.

"I have nothing whatever to do with dyes or dyestuffs. I am not interested in that. I shall not talk of the commercial side of it, but I know that the situation is very similar to the situation in the manufacture of other chemicals with which I am better acquainted. The whole chemical industry here in the United States does not have to blush at all when compared with that of other countries. It is, in fact, remarkable that this country should have done as well in chemical industry as history proves. The world's electrochemical industry has been mostly developed by pioneer inventors here in the United States, and this division of chemical industry has taken tremendous proportions here in comparison with that of Germany, which has specialized more in the manufacture of dyestuffs; in both countries these specialties have developed in accordance with the natural opportunities offered by each of them."

THE CHEMICAL INDUSTRY AND THE TARIFF

"To give you some relative values, the United States is making one particular product which is called oleomargarine. The exportation of oleomargarine from this country to Germany was larger than the whole importation of aniline dyes from Germany. There are some other conditions which have produced quite awkward situations here in this country. Since our tariff law became a political issue instead of a plain business issue, and since the tariff has been changed and changed and changed over again, chemical manufacturers do not know where they stand.

"I will give you one concrete example, because I have been identified with it. I have just now before me a proposition which involves the construction of a manufacturing establishment of several million dollars. It so happens that right here in the United States a process has been developed for making a product, which I do not want to mention now by its real name but which I shall call B. In order to manufacture that product you need another product which is called A, which is the raw material for B. Now, this product A is manufactured in Germany by patented processes, and the corresponding patents exist also in the United States, but the patents are not worked here. You can not manufacture B profitably unless you get A cheap enough, but it so happens that some company here in the United States had a little bit of a factory in which A was manufactured by means of an inferior and absolutely obsolete process; it had succeeded in influencing Congress to put a prohibitory tariff on A, to the point of protecting it by 50 per cent of the selling price of A. In other terms, when Canadians or Englishmen pay, say, 10 cents for the product you have to pay 15 cents in the United States.

"It happens that that small American concern does not produce 10 per cent of the total consumption of that product A in this country. To make matters worse, the product B—which could now be made by means of an American invention, and which is at the point of being manufactured on a large scale, except for these particular difficulties—this product B is one of the chemicals which has been put on the free list. The

manufacturers of B, with our lax patent laws here, under which it is easy enough to infringe a chemical patent, might be disposed to take chances and infringe the process patents of the product A and manufacture the product A according to the German patented methods. Indeed the American patent disclosed the manufacture of the product A, but it is an enormously different thing—Mr. Metz is a manufacturer and knows that—to manufacture a product, and to manufacture it profitably. In other words, the yield of 10 per cent, more or less, or a slightly better quality, will make a process a losing business or a paying business. Now if any of these people here, in order to manufacture the product B, try to infringe the patent A, or even if the German patentees of the American patent A gave them that patent A for nothing, but would not communicate them their long experience in manufacturing, so as to obtain maximum profitable yields, the use of that process would be unprofitable from a commercial standpoint.

"In the meantime the result of this situation is that very probably this new American process—the process patented in America for producing this product B—will be compelled to go and locate in Canada in order to get cheap A imported from Germany into a country where A comes in free of duty, and after having manufactured B in Canada, it will be more profitable to ship this product to the United States, because B enters duty free in the United States although the raw material A from which B is made is loaded with an enormous duty.

"This is one of the many examples I could mention of the absurd conditions with which some of our chemical industries have to contend in this country. It is not only a question of chemical patents, but also a question of tariff and a question of raw materials. And then there is another matter which must not be slighted, although it has not yet been mentioned here. The matter to which I am about to refer should not be exaggerated; but it exists nevertheless. I know of instances where German manufacturers have said, 'If you manufacture such or such a product in your country we will make it impossible for you, because we have an establishment here which is so big and so complete that we can supply the demand of the whole world. We can not afford to manufacture profitably on a small scale, and therefore must keep our full units working; and we will undersell you in the United States, which will drive you out of business. In the meantime we will raise prices in other countries where we have no competition, so as to compensate for any loss we sustain in underselling you in the United States.' "

Questioned as to the chemical industries of this country and England, Dr. Baekeland thought that unbiased Englishmen themselves will acknowledge that of late we have gone ahead considerably farther than they have done. But "if we are speaking about English inferiority in chemical manufacturing, this is only relatively true. We cannot say that England is not still a very superior and important chemical manufacturing nation. And when it comes to some of the industries in which they are masters we must recognize that even Germany is second, and in whatever thing those countries have specialized it has been according to the lines of least resistance. The English textile industries and the English metal industries are so important in England that she can well afford to neglect some of her chemical dye industries or other mechanical industries, about the same way as in this country for a number of years we quite naturally gave far more importance to the industries of mining, transportation, and the mechanical industries generally. There was no need of chemical industries. It is not so many years ago that the manufacture of sulphuric acid on a large scale was practically impossible in this country. Why? Because there was no market for it. We are now, I believe, the largest sulphuric acid producing country in the world. I do not think there are any countries which produce more sulphuric acid than the United States. It required natural opportunities—the discovery of the phosphates to make superphosphates, the dynamite and explosives industry, the refining of petroleum in order to create a market for sulphuric acid.

"It is the same thing with the dye industries. The dye industries, unfortunately, are broken up into many little side branches, relatively small matters which in this country would by themselves be almost beneath the dignity of a man of enterprise to bother with. In Germany they can do it collectively, and why can they do it collectively? Because they can do a good many things there which would not be tolerated by the laws of this country. You all know—it has been mentioned here—that those German aniline industries make up an immense trust. They have agreements as to price, as to markets, and as to the restrictions of sale and restriction of production; and if there are any new patents, if one factory buys one patent the other can use that patent." . . .

"I visited one of those works. They do not look like factories; they look like well-organized towns. They treated me with unusual consideration, because they showed me what they very seldom do to visitors—several departments of their plants, and, in fact, some departments I was enabled to study for several days in succession. They took me in an automobile to drive around the plant, and it required the better part of the afternoon to run through the many streets of their plant and to visit hastily each of the many buildings." . . .

"There is another matter I want to call your attention to. The American promoter ordinarily wants to get rich quickly. He does not want to trust to any industry which requires slow but healthy development. A couple of years ago I spoke to the director of one of those large (German) enterprises, and he seemed pretty well imbued with the idea of the importance and development of his plant, and I asked him what dividends they paid. 'Oh,' he said, 'we are paying as much as 28 or 30 per cent dividends.' 'Well,' I said, 'that is a lot, but what does it amount to in dollars and cents?' Then he told me what it amounted to, and I was amazed at how little it was relatively speaking. I said, 'Have you any water in your capital stock?' 'No; that is not allowed in Germany.' 'Have you amortized any of your buildings?' 'Oh,' he replied, 'quite some.' I said, 'Then do you mean to say that your capital stock is considerably smaller than your real assets?' 'Yes,' he said. 'When did you start?' 'In 1862.' 'Do you mean to say,' I asked him, 'that after 50 years, that is all you have to show?' 'Yes,' he said; 'we are entirely satisfied.'

"Now, in America any third-rate industrial enterprise—badly managed as some of them are—at the end of 50 years would be ashamed to declare a dividend of that kind, if you calculate it on unwatered stock; but those people are satisfied with small profits. I know it, and I know furthermore—and probably Mr. Metz knows it, because he is a manufacturer, too—that some of their departments work at considerable losses. A large number of those departments do not pay at all. Some other departments pay better, and they equalize or offset the losses, and they seem to be satisfied with the ultimate result. But if you take those dividends and compare them with the dividends of some American concerns on the basis of their watered stock, their returns are disappointingly small from the American point of view.

"Gentlemen, there is one thing that you could do. I

have spoken of it to your chairman, and I wish to take the liberty of repeating it. If you really want to render any service to the industrial development of this country, and more particularly to its chemical industries; if you aim at any change in our patent laws, please arrange matters in such a way that patent litigation becomes more direct, less complicated, and less expensive. The way patent protection is now administered in our country is a gross absurdity, and no safeguard for chemical industries based on improvements and pioneering enterprises."

Mr. Metz said that the dyestuff imports into the United States are about $1,000,000 a month; $12,000,000 a year will cover all the importations of dyestuffs and raw materials for dyestuffs. "I want to emphasize that point as to the relatively small value of these things in proportion to the size of the industry into which they go—cotton, silk, wool, paper, typewriter ribbons. There is scarcely an industry that is not affected. Even the ink for the red headlines in the newspapers—those have had to be discontinued. The total new profit to the manufacturer of these materials (at a normal average profit of 25 per cent) would be at the maximum $250,000 a month, as compared with the entire business of the United States. If the German manufacturers shut down entirely they would lose almost nothing, but we would lose hundreds of millions of dollars for the lack of stuff to keep our mills going. That is why the Germans are not anxious to-day to export a single pound; it is a favor to us. They want to keep these things out of England. That is their business, if they want to do it. They do not want to let a single pound of these materials go to England or France or any manufacturing country, and they are afraid that if they give us any more we will send it to those countries. The trade in those products is a very small factor with Germany, and anything that will tend to prevent the importation of those things at this time will injure us to an extent that will far more than offset any benefit we will get."

Dr. Baekeland in concluding said: "I know that the importation of coal-tar dyes into this country—although it amounts to $12,000,000 a year—is a small item compared with a lot of other items of which we have not spoken at all. For instance, I know that New York City consumes in one year eggs of a value two and one-half times as great as the value of all the aniline dyes imported in one year into this country. Any man who could make a law to increase the size of eggs by one gram would make himself infinitely more useful to his country than a man who could increase the production of those aniline dyes. In fact, the trade in sheep manure for tanning and other purposes is about equivalent in value to the value of aniline dyes imported into this country."

The hearing was then adjourned.

The **Engineering Foundation** was inaugurated with appropriate exercises in the United Engineering Building, New York, on the evening of January 27, 1915, under the auspices of the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, the American Institute of Mining Engineers, and the American Society of Civil Engineers. A gift of $200,000 by Ambrose Swasey, designer and builder of the Lick, Yerkes and U. S. Naval Observatory telescopes, and an engineer, scientist and astronomer of high distinction, forms the basis of the Foundation. Mr. Swasey is a member of the firm of Warner & Swasey, machine tool builders, of Cleveland, Ohio, and a past president of the American Society of Mechanical Engineers. The principal speech of the inauguration exercises was made by Dr. Henry S. Pritchett. The fund will be used chiefly for research work.

Dinner to Frederick G. Cottrell

A dinner in honor of Dr. Frederick G. Cottrell was held on the evening of January 15 at the Plaza Hotel in New York City, under the auspices of the American Institute of Mining Engineers, the American Electrochemical Society, and the Mining and Metallurgical Society of America. The occasion was graced by the presence of many ladies.

The purpose of the dinner was to honor Dr. Cottrell for the service rendered by him to the advancement of science, as stated in the following minute, adopted on the same day at the annual meeting of the Research Corporation and distributed appropriately in printed form at the dinner:

"In 1911 Frederick G. Cottrell, B.S., Ph.D., offered to transfer to the Smithsonian Institution substantially all his rights in his inventions and patents covering the processes known as the electrical precipitation of suspended particles in order that the profits resulting from the application of the patents, already well assured, might be applied to the advancement of scientific research and investigation. Naturally this proposition was at once recognized as both generous in spirit and highly original in conception. It was Dr. Cottrell's ideal to render discovery already made the mother of new discovery, and thus contribute to the scientific and technical development of the industrial arts.

FREDERICK G. COTTRELL

"This far sighted and patriotic conception found its realization through the Research Corporation which for administrative reasons was substituted for the Smithsonian Institution as the custodian of Dr. Cottrell's endowment. The objects of the Research Corporation as stated in its charter are: 'To provide means for the advancement and extension of technical and scientific investigation, research and experimentation by contributing the net earnings of the corporation, over and above such sum or sums as may be reserved or retained and held as an endowment fund or working capital, to the Smithsonian Institution, and such other scientific and educational institutions and societies as the Board of Directors may from time to time select in order to enable such institutions and societies to conduct such investigations, research and experimentation.'

"Organized in 1912 as a stock corporation but precluded by its charter from paying dividends and capitalized by a group of gentlemen desirous of furthering Dr. Cottrell's objects, without personal profit, the Research Corporation undertook and successfully accomplished the installation of the Cottrell processes in various industries throughout the country, with the result that in two years' operation its surplus has provided the capital of twenty thousand dollars required by its charter, and a fund of over one hundred thousand dollars for scientific research.

"The accomplishment of this remarkable result, which both justifies Dr. Cottrell's expectations and realizes his hopes, is due to his generosity and foresight, and the

PHOTOGRAPH TAKEN AT DINNER TO DR. FREDERICK G. COTTRELL

Directors of the Research Corporation take this occasion to express to Dr. Cottrell their appreciation of his contribution to scientific achievement and to the advancement of science, and tender him their cordial congratulations and sincere thanks for the public service which he has rendered."

Mr. SIDNEY J. JENNINGS presided at the dinner. In his introductory remarks he spoke of mining as the basis of civilization and of Dr. Cottrell as a very practical idealist. He proposed a toast to Mrs. F. G. Cottrell, who had been compelled to stay in California and could not witness the tribute of esteem and affection paid to her husband.

Dr. CHARLES D. WOLCOTT, director of the Smithsonian Institution, spoke for the Research Corporation. He related how Dr. Holmes had brought Dr. Cottrell to him and how the organization of the Research Corporation finally resulted. He spoke of the many practical problems which are being taken up or are to be taken up by the Research Corporation, and of Dr. Cottrell's idealism.

Mr. WILLIAM L. SAUNDERS then spoke for the American Institute of Mining Engineers. He said his experience with inventors had been as extensive as it had been expensive. One of the directors of the Research Corporation had told him that the Cottrell patent was worth one million dollars. "This is not at all an unfamiliar statement about a patent to me, though the novelty of it is that heretofore I have heard it only from the inventor. An inventor with a patent, whether it relates to a clothes pin or a submarine, invariably rates its value at one million." Mr. Saunders related forcibly a wonderful story of a dynamite inventor with a patent alleged to be worth a million. The story was fearsome, but had a happy ending. Mr. Saunders concluded:

"But the controlling thought with all of us to-night—the impulse which has drawn us together—is not that we wish to do honor to a great inventor, but to the man. Ours is not a compliment to the brain, but to the heart. That which we so regard, that to which we pay the homage of our admiration and cheers is that one of our kind should be so unselfish as to dedicate this valuable product of his brain to the public good. In doing this he has not only rendered a great service to mankind, but he has set a wholesome example to present and future generations.

"The governor of a western state, who was also a member of the board of directors of a railroad company, told me the following story: He was presiding over the annual meeting of the directors in a western town when a man opened the door of the room and after politely apologizing for the intrusion asked for a few moments' attention that he might explain his plan by which a large sum of money would annually be saved to the railroad company. The first impulse was to put him out, but he held his ground by the statement that as the directors were there for the purpose of saving money for the company, and he stood ready to help them, they should at least let him explain his business. He then said that he had a patent oil for railroad use, the virtues of which he was diligently expounding when the superintendent entered the room in response to a bell call and was ordered to give the patent oil a trial.

"On the year following, these directors met at the same place and recalling the incident the chairman asked the superintendent what was the result of the trial of the patent oil. 'All right,' said the superintendent. 'It is a satisfactory lubricant.' 'Well, I'm glad to hear that,' said the governor; 'the interruption at our meeting last year was a good thing after all; that fellow must have a valuable patent.' 'Governor,' the superintendent replied, 'the value of that patent *is that man.*'

"And so it is in this case, for the economic worth of Professor Cottrell's invention, as high as we know it to be, cannot equal that real value of the patent which is that man. The man whom we so gladly and so unanimously honor this evening is deserving of our highest esteem, for 'hearing ofttimes the still, sad music of humanity,' he is built of such stuff, that,

"Too high for common selfishness, he could
At times resign his own for other's good."

Mr. F. AUSTIN LIDBURY followed, speaking for the American Electrochemical Society. He gave reminiscences of the time when he worked alongside Dr. Cottrell at Ostwald's laboratory in Leipzig, "a pleasure which those who shared it will not easily forget."

"Added to those personal qualities which have since won him a nation-wide circle of friends and admirers, we had the advantage of associating with one whose bold and brilliant ideas were only equalled by his ingenuity in devising and executing experiments to test those ideas. He was the most brilliant and original experimenter that I had ever met, and he used to startle us every day or two by producing some new marvel of experimental ingenuity. If he will permit me to say so, I must confess that if the first experiment did not work, it was rarely followed by a second one; but this was no doubt attributable to the fact that he came to us fresh from Van't Hoff's laboratory, where one was held pretty closely down to the determination of vapor tensions and solubilities; no doubt very excellent training, but rather calculated to arouse unruly thoughts in an ardent mind.

"I am asked to speak of Dr. Cottrell's work on electrostatic precipitation. Of the results and far-reaching importance of that work it would be presumptuous on my part to speak to this audience. Nor am I capable of describing adequately the quality of the work itself, or its importance. There are two points to which I would direct your attention.

The first is, that when Dr. Cottrell undertook his investigations the prospects were sufficiently discouraging.

"Electrostatic precipitation of solid particles from gases was no new idea; in particular, it had been experimented with by a famous English physicist, who had, however, not even succeeded in dispelling the fog in his own quadrangle. It did not look either to a scientist or to an engineer exactly the kind of thing that one calls 'practical.' Companies to whom the removal of noxious fumes from gases was a vital matter were not inclined to give the idea when presented to them very much consideration; it was altogether too good to be true; and while money might easily have been found for a small improvement which might look as though it would save a few thousand dollars a year in some detail of their properties, this was altogether too vital and too important a matter to spend money on.

"Under these circumstances, Dr. Cottrell simply went and did it. That is all there is to say in this connection.

"The second point is one which particularly concerns the electrochemist. At this moment, when the revolutionary electrochemical activities of the last decade but one have settled down into a kind of steady development, Dr. Cottrell's success comes as an inspiration to the electrochemist. It indicates to him that the large successes of electrochemistry in the future, the untilled field, are to be sought among the byways and hedges of that bastard technical science.

"But we have met to-night to recognize also Dr. Cottrell's eminent services as an experimentalist in social science. That he so regards himself is abundantly clear from the very interesting paper on the Research Corporation which he presented at the last International Congress of Applied Chemistry. I know few more interesting papers than this, and not its least interest lies in the fact that it is to a great extent a human document. No one, I think, can read this paper without being impressed by the extent to which it reveals that modesty which is one of Dr. Cottrell's chief characteristics.

"Now the particular branch of social science in which Dr. Cottrell has interested himself is that which embodies the relations between the universities and the technical industries. I doubt whether any more fruitful subject for discussion than this has been before scientific people in the last few years. One is reminded of the old Scotchman who was visited by his minister when he was lying on his death bed. 'Sandy,' the minister said, 'shall I read ye a little from the good book?' 'Nay, nay, meenister,' said Sandy, 'sit ye down and let's argue a wie.' Certainly there has been enough argument on this question. Most diverse positions have been assumed; the head of one of the largest research laboratories in this country has been bold enough to state that the time has now arrived when the universities must yield research to large technical industrial organizations, just as centuries ago the church yielded research to the universities. My friend's boldness was, however, tempered with discretion, as he published his article at a time when those who might be expected to be interested in combative issues were taking their vacations.

"Dr. Cottrell stands emphatically on the other side of the question, and his notable contribution is that while, with practically one other exception, the parties to the discussion have confined themselves to discussing, he has gone at the matter in an experimental way. And not only so; experimental research is expensive; and Dr. Cottrell has put at the service of the experimental work on this social question what would have been a most munificent gift from any man on earth; and what, coming from one who is a poor man, is only to be described as unparalleled. Only a scientist in the truest and rarest sense of the word would be capable of such generosity or such self-sacrifice. He has made an indescribable sacrifice in order to try out on an enormous scale the social idea.

"It only remains for me now to wish the Research Corporation every success. Its responsibility is commensurate with the generosity of Dr. Cottrell's gift. It will not find other Cottrells—they do not grow on every bush."

Mr. WALTER RENTON INGALLS spoke for the Mining and Metallurgical Society of America. He mentioned that Dr. Cottrell's official title is that of chief physical-chemist of the U. S. Bureau of Mines.

"If any here present this evening may not happen to know just what a physical chemist is, they need experience no mortification or entertain any notion that their early education was neglected. The physical chemist is, indeed, a rare bird of a new species. Those of us who possess sheepskins dated in the early eighties and in the middle eighties, pursued courses in chemistry and courses in physics, but at that time it had not occurred to anybody that we ought to study the two together. This did not happen until later, and for the reason that the older chemists and metallurgists were not taught the rudiments in the right way they have always been at a disadvantage compared with those of the younger generations, no matter how seriously they have tried to correct the deficiency.

"We are very much like a coachman who was converted into a chauffeur. In the early days of the automobile the chauffeurs as a class possessed a very bad reputation, which no doubt they richly deserved. A certain gentleman, desiring to avoid the evils of grafting, joy-riding, etc., conceived the idea of making a chauffeur out of his honest, reliable and intelligent coachman, and for that purpose sent him to an automobile school of instruction. After three months or so, James returned proudly exhibiting his diploma. 'Yes, sir,' said he, 'I have learned all about the automobile. I know how to put in the gasoline and how to put in the oil. I know how to adjust the carbureter and how to clean the spark plugs, and how to scrape the carbon from the cylinders.' Then waxing confidential, he added, 'Yes, sir, I know all about the automobile engine, but there is one thing I have never been able quite to get into my head, and that is, what makes the blame thing go?'

"Many of us are in the same position with respect to chemical reactions and metallurgical processes in the light of modern theory. We have learned how to pull some of the levers and press some of the buttons, and make things go, but why they go we do not always understand as well as we ought to. We are apt to be strong upon the means how, but weak about the reasons why. Therefore, we sit at the feet of the masters of physical chemistry, among whom is Dr. Cottrell—the modern science in which is wrapped the whole future of metallurgy.

"Now, even before physical chemistry became a science we smelters of an olden time were having our experiences with the gentle art of smoke farming. We were all quite familiar with the agriculturist of our neighborhood who, from time to time, used to call at our works and complain that our sulphur smoke had damaged some especially promising field of corn; or that old Dobbin had developed a spavin, which was probably due to our sulphur smoke; or that the chickens had fallen sick of the pip, for which our sulphur smoke again was to blame. We used to sympathize with our bucolic friend, and wonder whether $50 might compensate for damages, assuage injured feelings, etc. Generally, they allowed that it would, and disappeared for six months, a year, or whatever time they considered to be a proper interval between contributions.

"But as our smelting works became larger and more profitable, so did the avarice and aspirations of the smoke farmers increase, until at length their demands became so onerous that no smelter could agree to them and hope to continue solvent. The consequences were suits for damages, court injunctions, and the development of smelters' smoke as one of the great metallurgical questions of the day, engaging the attention of scientists all over the world. Among these was Dr. Cottrell.

"Dr. Cottrell was acquainted with the experiments of a distinguished British scientist, to whom Mr. Lidbury has already referred, for the settling of London fogs by electrical means. Those experiments had, however, resulted in nothing useful, and the idea of electrical precipitation had been generally dismissed as fruitless. But not so by Cottrell. It was on the point of my tongue to say that Cottrell was from Missouri, but I have happened to remember that in fact he is from California, and anyhow I have never taken much stock in the quality commonly ascribed to Missourians of sticking fast to the idea that seeing is believing. Tell a Missourian that in the firmament above us there are three trillion, several billions, millions and thousands and three hundred and sixty-seven stars and he will believe you without question, just as will a Hoosier or a Yankee. But show a Missourian a place marked 'wet paint' and he will immediately try it with his finger. In fact, human nature is about the same everywhere.

"Well, anyway, Dr. Cottrell prosecuted his investigations, made his inventions, and proved his theory to be correct, and in a surprisingly short period of time we have seen his process attain great importance in our metallurgical industry. And, not only in that, but also has it found applications in other industries. Dr. Walcott has mentioned some of these. It is used for allaying the troublesome dust in cement works. It is used in the preparation of certain powdered foods, especially powdered milk and powdered eggs. It is possible that some of the delicious confections that we have eaten here this evening were prepared by the baker of this hotel with the aid of Cottrell powdered eggs. If not, I submit that the dinner committee should have seen to it. Surely, there is no one here who would not have taken such a chance—once.

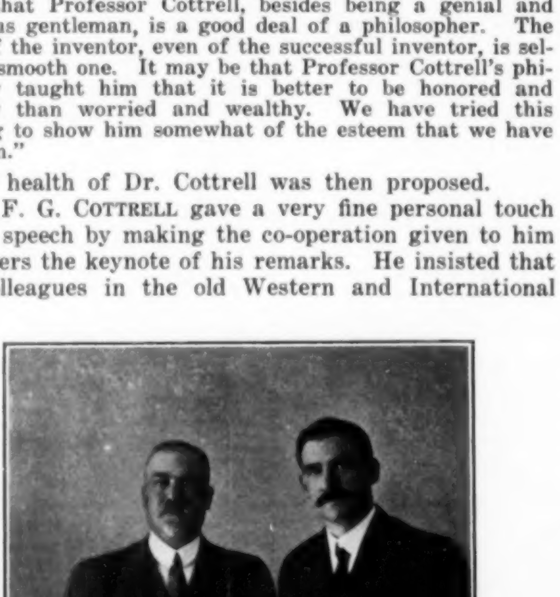
"I understand that Dr. Cottrell, not satisfied with the

accomplishments that already are remarkable, is contemplating other Romes to conquer. I believe that he entertains serious ideas of abolishing the smoke of Pittsburgh. If he succeeds in doing that, I do not venture to prophesy the size of the monument that Pittsburghers will erect to him at the junction of the Allegheny and Monongahela rivers.

"Professor Cottrell munificently gave away his process in the interest of science. Mr. Saunders has told us that this process, even in its kindergarten days, is considered to be worth a million dollars. There are not many men who would give away anything worth a million dollars. But we know that Professor Cottrell, besides being a genial and generous gentleman, is a good deal of a philosopher. The path of the inventor, even of the successful inventor, is seldom a smooth one. It may be that Professor Cottrell's philosophy taught him that it is better to be honored and healthy than worried and wealthy. We have tried this evening to show him somewhat of the esteem that we have for him."

The health of Dr. Cottrell was then proposed.

Dr. F. G. Cottrell gave a very fine personal touch to his speech by making the co-operation given to him by others the keynote of his remarks. He insisted that his colleagues in the old Western and International



FROM LEFT TO RIGHT: STANDING, E. O'NEILL, F. G. COTTRELL; SEATED, E. S. HELLER, H. E. MILLER

Precipitation Company should be named with him as co-donors of the patents to the Research Corporation. The first to assist him had been Dr. Harry East Miller, to whose private laboratory in San Francisco the experimental work had been transferred at an early date after it had been started at the University of California in Berkeley on a small scale. The earthquake and fire of 1906 finished this early work. Then Mr. E. F. Heller, a lawyer and business man of San Francisco stepped in, and Professor Edmond O'Neill of the College of Chemistry, of the University of California, became the fourth member of the coterie which carried on the pioneer work for five years until it was turned over to the Research Corporation.

Dr. Cottrell spoke of the help extended to him by Dr. Holmes, Dean Goetze, and others, of the late Dr. Duncan's idealism which resulted in the Mellon Institute for Industrial Research in Pittsburgh, of the international character of scientific organization, and finally paid a quiet and beautiful tribute to the help he had received in all his work from his wife, who had remained in the little bungalow in California while he had gone East on this trip. "You don't know a man until you know his wife."

Annual Report of the Bureau of Mines

In the fourth annual report of Dr. Joseph A. Holmes, director of the federal Bureau of Mines, he presents a summary of the work of the Bureau during the last fiscal year ended June 30, 1914, and discusses some of its needs. An interesting tabulation is made showing the country's relation to the two great basic industries, mining and agriculture, and the federal support given each. The salient facts are that agriculture shows an annual value of products $10,500,000,000 as against $4,600,000,000 for mining; but mining contributes 60 per cent of the freight tonnage of the country as against 22 per cent for agriculture. On the other hand, agriculture receives annually from the government for education, experiment stations and general research $27,970,000, as against $1,967,000. Agriculture is aided by 52 experiment stations for which $1,550,000 is appropriated, while mining receives no appropriation for such work. Bearing on the latter point, and in supporting the idea of mining experiment stations, the Director says:

"Owing to the magnitude of the country, the distances between the widely distributed mineral regions, and the marked differences not only in the nature of the mineral resources of this country, but also in the conditions under which they must be developed, it does not appear to be practicable to conduct efficiently at any one central point researches concerning all of these mineral resources. In addition to one or more central control laboratories, it is important that there should be established in a number of the more important mineral regions of the country local mining experiment stations at which researches may be conducted in keeping with the nature, mode of occurrence, and the development of these resources.

"There should be not less than 10, and probably need not be more than 15, such stations established, the larger number of which should be located in the public-land States west of the Mississippi River. These 15 mining experiment stations will do for the mining industry in this country a work comparable in importance to the work which is being done in behalf of agricultural advancement by the 52 agricultural experiment stations, for the maintenance of which Congress appropriates annually more than one and one-half million dollars, or $30,000 for each station.

"It is expected that the work of each of these mining experiment stations will be supplemented through appropriations made by each of the mining States in which such stations are to be located, and it is further expected that the appropriations made by the States will provide for such portion of the investigations as are local in their character and importance, whereas the investigations provided for out of the appropriations made by the Federal Government will be of a general or national character and importance.

"It is proposed that the establishment of these stations should be provided for through the enactment of special legislation which is now pending before both branches of Congress (H. R. 15869 and S. 5588). The importance of this legislation to the mining industry is such that it can hardly fail of enactment, and with its enactment the bureau will be able to take up and carry to successful completion researches which cannot fail to be widely useful in the upbuilding of the industry."

Leaching of Copper Ores and Electrolytic Precipitation was the subject of a spirited discussion, opened by a paper by Dr. L. D. Ricketts, at a joint meeting of the New York Sections of the American Institute of Mining Engineers and the American Electrochemical Society on January 6. A report is reserved for our next issue.

Handling Iron and Cinder at the Blast Furnace

BY J. E. JOHNSON, JR.

(*Concluded from page 50*)

Handling the Slag

When the blast furnace had its beginning it is almost certain that the slag was handled as clinker or ashes, and this point of view survived until very recent times in the crane-operated shovel, fork, etc., which I have described in a previous article as adjuncts to charcoal furnaces in the seventies and which were used to clean out and "work down" the furnace very much as we find it necessary to do with the average domestic heater to-day. The difficulties of this method of operation a growing knowledge of the use of flux, and the use of the hot blast with its correspondingly higher hearth temperatures brought the possibility of discharging the slag in the liquid condition and this practice became general though not universal in the early part of the last half of the nineteenth century.

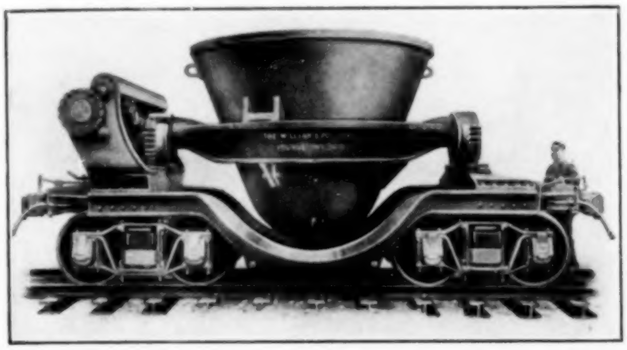


FIG. 15—POLLOCK CINDER LADLE

The slag was probably allowed to run out from the furnace with the iron, and after being skimmed off as previously described, was run off to a short distance into puddles in which it was allowed to cool. Slag being very brittle when cold is easily broken up by hand and was disposed of with carts or any convenient means, being simply loaded from the ground into the conveyance with shovels or forks. Carts dumped it into holes or low places, and sufficient of these were commonly found near the plant to take care of the slag output for many years.

Survivals of this method are in use even down to the present time, though they have now become rather rare. When mineral coal was substituted for charcoal as fuel, the quantity of slag produced per ton of iron increased to some extent, but probably not nearly in the ratio which the average volume of charcoal slag bears to that of coke slag per ton of iron produced to-day for the reason that in the early days of mineral fuel it was almost impossible to carry as much lime in proportion to the silica of the charge as we now know how to handle successfully. But even though the difference was not so great it was still very considerable and helped to bring about a change in the method of handling, because with small outputs of iron, and small ratios of cinder per ton of iron, the volume of this material to be disposed of was so slight that no highly organized methods were used for disposing of it.

But with the increase in volume of slag, and also the great increase in tonnage of iron, the importance of slag disposal grew even more rapidly than the question of handling the pig iron output, and a vast number of methods have been devised and practiced in trying to handle it with maximum economy.

A comprehensive search would be required to obtain a reasonably complete list of the methods which have been used on an industrial scale in the past, but as only a few of them have survived this is not needed, a description of a few of the most commonly used will suffice.

The first important development was the choice of a definite dumping place, chosen with the idea of affording room for slag disposal within a limited area for a long term of years and railroad transportation for delivering the slag to it.

Probably the earliest improvement was to run the cinder into long parallel runners roughly made up in coke brise so that the size of the individual bodies of cinder is limited, because while this material is very brittle as compared with iron, if it is cast into puddles of several feet across, and a foot or two thick, it cools very slowly, and this slow cooling anneals and greatly toughens it, so the difficulty of breaking it up grows very greatly with the size of the body into which it is cast.

When cast in long runners of approximately semicircular shape, a foot across, and six inches thick, it was handled with hooks, one in the hands of each of a pair of men, who broke the runner of cinder up into pieces, three or four feet long, and swung it onto a pile by catching it with a hook near each end. The sections of runner were piled roughly together and allowed to cool still further, after which they were loaded onto cars and taken away. This cleared the beds for the next fall of cinder.

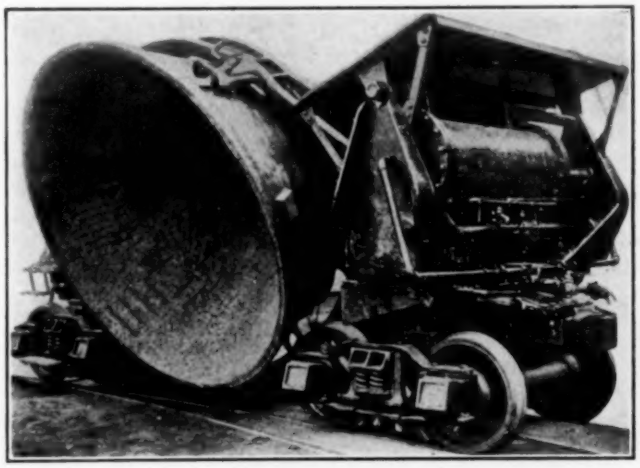


FIG. 16—TREADWELL CINDER LADLE

In other cases quite large holes, approximately round, were dug into the ground, the cinder allowed to run into these, and a bar or hook of iron stuck into the center while it was still hot. After the cinder had hardened it was picked up by this hook, with the aid of a crane, and loaded for disposal. At the dump the cake was broken up and the hook or bar of iron recovered to be used again.

In other cases the cinder was cast into cakes on cars made entirely of iron, which had a perfectly flat top, so hinged to the body of the car that it could be tipped laterally in either direction. On top of these were set cast iron frames, the section of a truncated pyramid with the sides sloping inward at the top, and without top or bottom. A joint between these and the deck of the car was made with brise or fine cinder, and they were run full of cinder direct from the cinder trough at the furnace. After cooling the iron frames or molds were lifted off with a crane, the train of cars taken to the cinder dump, and the decks tipped, allowing the cakes to slide off over the dump. In this case of

course, as with practically all dumps, the tracks must be moved either laterally or built ahead as the dumping space is used up.

About thirty years ago the practice of handling the slag in the liquid condition began to receive quite general recognition, and has developed continuously and rapidly from that time. The first liquid cinder cars were simply huge rectangular tanks of steel plate, lined with firebrick, mounted on trucks, with a spout closed by a hinged gate at each side. The gate was closed, a little cold cinder thrown against it, and the tank was then filled with liquid cinder and hauled away. At the dump the gate was swung aside and the chilled cinder over the opening broken through, and the contents of the car then ran out. But this method was open to serious objection because even when very quickly handled slag forms quite a heavy skull under such conditions, and this skull fastening itself to the brick-work grows with each successive filling and emptying of the car until the capacity is so diminished that it must be cleaned out by hand, a laborious and time consuming operation. If the car were allowed to stand until the cinder froze on top it made matters still worse as this additional skull also had eventually to be handled by hand.

To eliminate these difficulties cars which dumped their contents by tipping bodily over were developed. These also were at first made of steel plate lined with firebrick, but even when emptied by tipping over they skulled up quite rapidly, and it was finally found that cast iron pots could be successfully used, and that being smooth inside the skull freed itself from them very much more readily than from the brick. These at first were made of the same shape as the steel plate ones had been, with almost straight sides, and flat bottom which gives maximum capacity, but it was found that by increasing the taper of the sides the pots could be made not only to dump cleaner, but to throw out the skull in the dumping position without barring or hand cleaning. Consequently such pots are now universally made with so heavy a taper that they are almost true cones, having only a small spherical bottom.

The design of the William B. Pollock Company is shown by Fig. 15 and that of the Treadwell Engineering Company by Fig. 16. Much ingenuity has been expended in devising the best mechanism for controlling the movement of these pots and dumping them with the least labor. After they had been in use for some years with the dumping gears driven entirely by hand, Mr. Samuel Stewart, then master mechanic of the Woodward Iron Company at Birmingham, Ala., patented a successful design in which a steam cylinder mounted on the car and connected to the locomotive, supplied the power for dumping and restoring the pots to their normal position without any labor and in much less time than was required for the hand-operated pots. This idea has now been applied universally to these pots, but with the very general equipment of locomotives with compressed air for brakes air is used to operate the cylinders instead of steam. With this device a whole train of these cars can be tipped, emptied, the skulls thrown out, and the cars restored to normal position, in a period measured only by seconds.

By the use of these side dump pots the dump may be built up approximately to track level on the dumping side so that the tracks can be moved over with but little labor, when the drop from the cars is no longer sufficient to free them properly, but cars of this type do not permit dumps to be carried ahead except by the laborious method of building up the dump at the end of the track by hand filling.

In order to make room as fast as it is used up, it is generally very desirable to build a track ahead, and for this purpose other types of cars have been devised. The earliest of these was the design of the late John M. Hartman. It consists of a half cylinder of steel plate lined with firebrick, with an extension around the top of cast iron plates, one side of the cylinder being flared out to make a pouring lip and the other side built up vertical. This half cylinder rests on a four-wheeled truck, to which it is fastened by two pairs of chains, one with the front end fastened to the cylinder and the back end to the truck, the other with the back end fastened to the cylinder and the front end to the truck, one pair of these being on each side. These act practically like a rack and pinion and leave the cylinder free to roll on the truck without the possibility of being displaced endwise by sliding; it is guided laterally by angle iron half rings riveted to the cylindrical surface, which work between guides on the truck.

These cars are not coupled directly to the locomotive but by means of a push pole sixteen to twenty feet long. After filling at the furnace these cars are taken to the end of the dump, the truck locked fast on the track with a powerful brake or "scotched," the locking mechanism of the body released and the half cylinder pushed over by the locomotive operating through the push pole which is fastened to the car with a swivel coupling.

The disadvantage of end-dump cars is of course that only one can be dumped at a trip, and if several have to be handled as many tracks must be provided as there are cars, or nearly so, because the heat at the end of the dump is too great to permit dumping one car immediately after another, and of course a separate switching operation is required for each car dumped, in fact two of them when more than one ladle car is used, one switch to dump the car and set it out, another to pick it up and take it back.

FIG. 17—BROWN HOIST CRANE LOADING CINDERS FROM PIT ONTO RAILROAD CARS

It is a curious fact that these cars build a dump which is almost precipitous in its slope, both on its sides and on the front. A "fill" can be constructed from them with great economy of material because its sides are almost vertical.

On the other hand, the side dumped cars produced very flat slopes. As little as ten or fifteen degrees suffices to carry the slag away from the track with this type of car.

Another type of end dump car with a round "thimble" like that of the side dump car is made by the Treadwell Engineering Company and works with a similar mechanism, but fore and aft instead of laterally. It is of course a more difficult design because the truck is in the way

of a free end-dump, but this difficulty has been successfully overcome.

How a slag dump is to be handled is very largely a matter of local conditions, but I have always felt that the benefits of the end dumped car for building ahead were not properly appreciated, and that the ideal combination would be two or three, or even four or five side dump pots with an end dump pot on the front. With this arrangement all could be dumped simultaneously without switching, and the end-dump pot would build ahead about as fast as the side-dump pots used up the track room it provided.

FIG. 18—BROWN HOIST TRAVELING CRANE AND GRAB BUCKET FOR HANDLING CINDERS

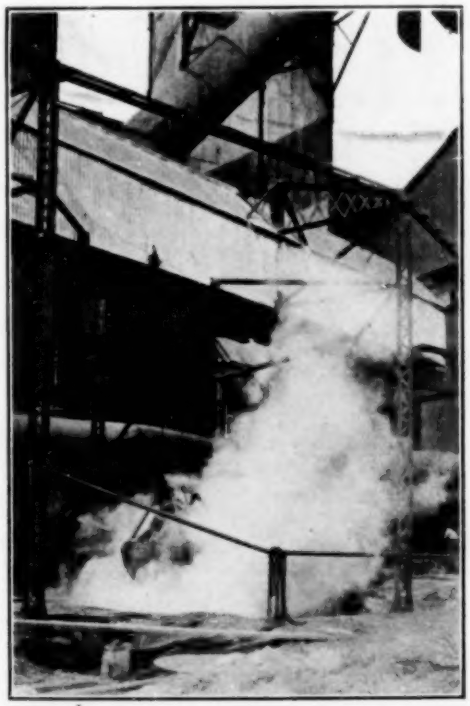


FIG. 19—BROWNING GRAB BUCKET RISING OUT OF PIT WATER DRAINING OFF

The "hot pot" method of handling slag is economical for a large plant of furnaces, and where dumping room is available within a reasonable distance; but in congested districts where the only available land between high bluffs and a river is a narrow strip of bottom, every inch of which is necessary for plant and railroad tracks, it is not always easy to find a place in which to dispose of the slag without a long chance that one will be exceedingly sorry for having put it there later on. Of course if a river or harbor can be filled to the harbor line this makes an ideal condition, but one which will not last indefinitely. Moreover, this method of handling slag requires a locomotive and crew in absolutely constant attendance day and night, Sundays and holidays. If the cinder cars get off the track, which not infrequently happens on the rough tracks on the dump, and the cinder train is blocked, the furnace may be put to desperate straits before the situation is relieved by the return of the cinder cars. The expense of the locomotive and crew is just as great for a single furnace as it is for three or four, and the cost of slag disposal per ton of iron produced is therefore very much heavier by this method in small plants than in large ones.

Granulation

These difficulties have prevented the universal adoption of this means of slag disposal, and have caused the development of others, of which by far the most important is "granulation." This was first practiced in this country, so far as known to me, by Captain T. C. Jones, I think, at a small blast furnace near Lynchburg, Va., and was subsequently applied by him, and still continues in use, at a furnace at Iron Gate, Va., where the slag is flushed directly into the James River and carried away by the current of that stream. The method consists in running the cinder out through a trough with a projecting end, just beneath which is placed a flat jet or nozzle about the same width as the trough. When the cinder starts to run a powerful current of water is turned into this nozzle, and the cinder running from the end of the trough falls onto this jet whose velocity is sufficient to tear the cinder into small shot as it runs, and these, of course, are prevented from recementing by the chilling action of the water.

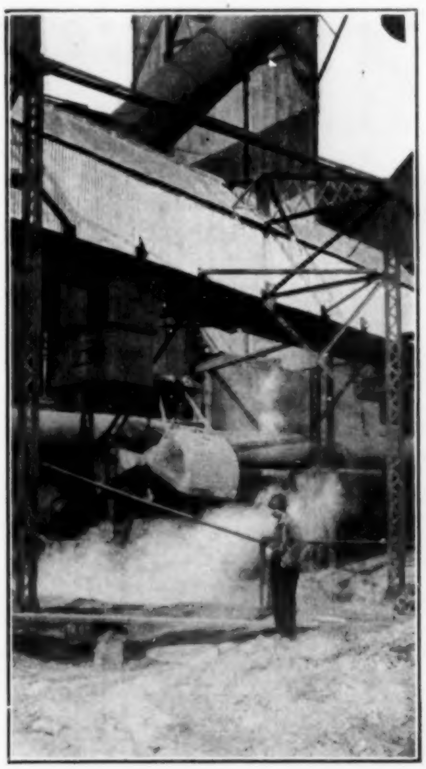


FIG. 20—BROWNING GRAB BUCKET OPEN OVER PIT

Most plants which use this method of slag disposal are not so located that they can flush the cinder directly into a river, and these have installed a huge concrete lined pit or tank sunk in the ground, into which the cinder and water from the jet fall together, and from which the cinder is recovered, generally by means of a clam shell bucket, and loaded onto cars. It is by that time cold so that there is no danger of fire; the cinder

is between course sand and fine gravel in size, generally rounded, and a very easy material to handle. It of course may be carried any distance desired to make fills on railroads, or the like, since the time element does not enter into its disposal as it does when handled liquid, and it can be handled virtually without expense in outward bound empty cars, and has in the past been very generally handled in this way by the railroads, without charge on account of its value to them as a filling material.

The clam shell bucket for recovering the cinder from the pit is operated in various ways, either by an overhead crane, a crane trolley without lateral movement, or by a locomotive crane running on a standard or broad-gage track. An arrangement of the latter kind may be seen in Fig. 17, which shows a Brown Hoisting Machinery Company crane engaged in this service. The pit cannot be seen, but its position can be judged from the ropes running from the end of the boom down to the clam shell which is out of sight in the pit, also

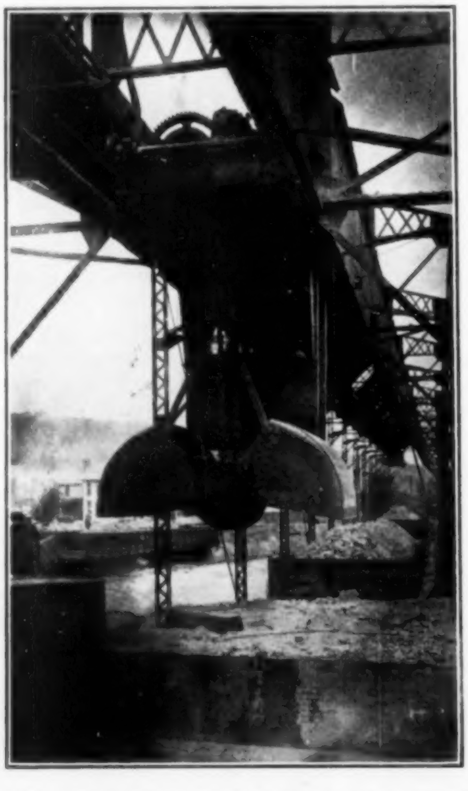


FIG. 21—BROWNING GRAB BUCKET OPEN OVER PIT

by the steam rising from it. The granulated cinder is raised out of this pit and swung over into the hopper cars from which steam is seen rising on the right hand side of the picture.

Fig. 18 is a view of the same plant and crane from a different position. The pit may be distinguished by the steam rising from it at the extreme left of the picture, while the white granulated slag in the car showing just under the crane boom is plainly visible.

Fig. 19 shows a clam shell operated from a trolley on an overhead runway, installed by Victor R. Browning & Company of Cleveland. The clam shell just at the top of the pit may be clearly seen with the water contained in the slag running from it. The clam shell open, dropping into the pit, is more plainly shown by Fig. 20. In this the perforations in the bucket for allowing the water to run off are plainly visible. The clam shell in its open position with the cars of loaded slag under the runway, are clearly shown by Fig. 21.

A different design by the same company of the same general arrangement is shown by Fig. 22

The trolley for handling the bucket with its mechanism and the operator's cage are shown by Fig. 23.

This method of handling slag has the great advantage that it gives several hours leeway, since slag can be stored in the pit without requiring to be removed for a

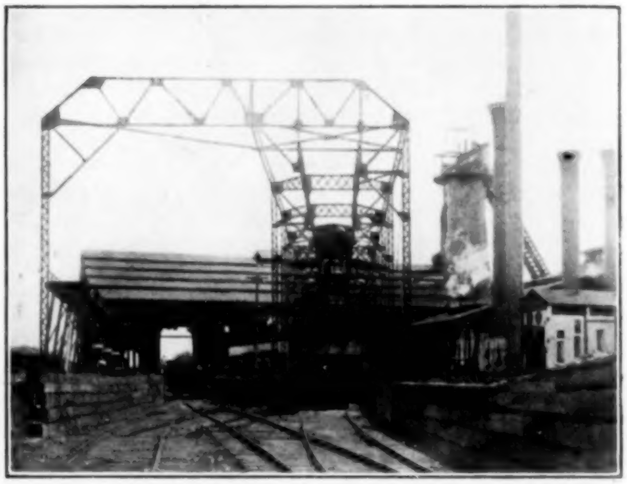


FIG. 22—BROWNING CRANEWAY WITH TROLLEY AND GRAB BUCKET

considerable period, so that breakdowns of the slag handling apparatus may occur without necessitating the shutting down of the furnace.

By providing a pit a little larger than common it would be very easy to store the slag for twelve hours or more, and so eliminate the operation of the slag trolley on one shift. Where the railroads take the slag, and the shifting engine is available for handling empty and loaded cars, this method is more economical for a single or even for a two-furnace plant than the liquid cinder method because it can be run by a single oper-

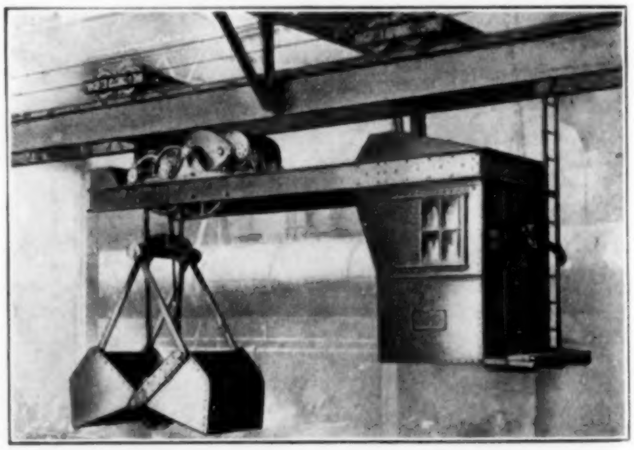


FIG. 23—BROWNING MAN-TROLLEY AND GRAB BUCKET

ator, whereas the other requires a locomotive and crew of two shifts as before stated.

Casting the Cinder and Handling It Cold

In recent years, since the very general introduction of concrete, it has been realized that slag allowed to cool slowly made one of the best aggregates that could be found, much better than limestone, because being of igneous origin it does not break up under the action of heat, as limestone has been known to do in case of fire.

Cinder is exceedingly rough and therefore furnishes an excellent bond for the cement, and in general cinder concrete is very highly esteemed by those who have used it.

Cinder is often recovered for concreting and road filling purposes by blasting the dumps made by ladle cars and loading them up with a steam shovel, but the cinder has generally run out in thin sheets which do not weld together, so that the mass breaks up into quite small pieces when it is reloaded. Moreover, this process requires the double operation of removing the cinder in pots and then picking it up with the steam shovel.

Mr. D. T. Croxton, of the Cleveland Furnace Company, some years ago, initiated the plan of casting the cinder directly from furnace in the old-fashioned way, but handling it by mechanical means after it was cold, crushing, screening and selling it for concrete material.

After a course of development for several years in which he installed a considerable quantity of special machinery, he finally came down to the simple practice of bedding heavy chains into the cinder bed before casting the cinder into it, these chains being covered up so as to prevent the slag from burning them. The slag bed is served by an overhead crane which takes hold of the ends of the chains at the sides of the bed and pulls them up through it. These chains are spaced a few feet apart and this breaks the slag bed into a material which can readily be picked up by a modern clam-shell bucket and loaded into cars for delivery to the crushing and screening plant.

This system without the mechanical equipment for handling the slag has been in use at other places where the slag has a commercial value as filling or building material.

One considerable advantage of handling the slag in this way is that a magnetic separator can be introduced into the path of the crushed slag and used to recover from it a considerable quantity of iron in pieces from the size of a pin head up to several pounds weight. This is true even with good furnace practice and where no important quantity of iron is visible to the eye, since the iron is so much heavier than the cinder that it goes to the bottom and is covered over by the latter.

It has been the experience of almost everyone who made any attempt to recover iron from the slag to find more than was expected when the attempt was begun. I myself had once the pleasant experience of putting in a magnetic separator in the hope of recovering four or five tons a month from a charcoal furnace, and actually recovered fifteen to twenty-five.

Many other methods of handling cinder have doubtless been used and perhaps a considerable number of these are still in operation, but the ones here described cover all the important methods in use on a large industrial scale.

The sampling and analysis of coal is treated at some length in *Technical Paper* 76 of the U. S. Bureau of Mines. Methods of sampling and analysis and interpretation of results are given in detail.

The Electric Furnace in Metallurgical Work is the title of *Bulletin* 77 of the U. S. Bureau of Mines. It is a compilation of data and useful information for the use of persons interested in the subject. Part I, by D. A. Lyon and J. F. Cullen, is devoted to the design, construction and operation of electric furnaces; part II to the smelting of metals in the electric furnace, by D. A. Lyon and R. M. Keeney; and part III to the manufacture of ferro-alloys in the electric furnace by R. M. Keeney.

The Arizona Copper Co. produced 1201 tons of copper during December, 1914.

Tube-Milling for the Flotation or Oil-Concentration Process

BY W. B. EASTON

In the December number of *Metallurgical & Chemical Engineering* there is an interesting article by Mr. W. J. Pentland, entitled "Notes on Tube-Milling in All-Slime Cyanide Practice." Under heading, "Duty of Tube Mill," Mr. Pentland questions the use of the tube-mill in closed circuit as being the most efficient method of using that machine. In regard to this phase of tube-mill practice, one hears the statement so frequently nowadays by engineers and millmen generally, that *"the most efficient machine is the one which keeps the greatest quantity of pulp in closed circuit,"* that I had nearly ceased to consider it as a debatable question. However, this statement may be no more axiomatic than the one that "the proper percentage of moisture for tube-mill feed is 38 per cent."

During the summer and early fall of 1914, I spent three months daily watching the operation of a 72" x 20' tube-mill. This tube-mill was fitted with the Chalmers & Williams patented adjustable quick discharge, and was running on split feed with conical tube-mills crushing copper ores for the flotation or oil-concentration process.

It is not the purpose of this article to make comparisons of the work of the two types of machines, but to use the results of some of the observations made during this time to throw some light on the question of the desirability of operating a tube-mill in closed circuit with a classifier, in order to obtain the highest efficiency from the tube-mill; and, incidentally, to show that with this type of tube-mill at least, there is no law which makes it necessary for the tube-mill feed to contain 38 per cent of moisture, for the percentage of moisture in the feed varied from so dilute a pulp as two parts of water to one part of ore, to only 29 or 30 per cent moisture.

The tube-mill under observation was used to prepare ore for treatment by the oil-flotation process for recovering the mineral; but the same conditions which would make the mill most efficient for this work would also make it most efficient for preparing ore for treatment by cyanide or, in fact, any subsequent process. It was decided, in order to get the best results from the oil-flotation process, to have the pulp as it left the classifier contain about 2½ parts of water to one part of ore, as it was desired to send the pulp directly to the oil-flotation machines without the intermediate operation of dewatering it. Naturally the work of the classifier was very materially affected by this thick pulp, but in reducing the capacity of the classifier to separate the finished product from the oversize, it brought out very clearly the effect of the classifier on tube-mill efficiency; for, if the classifier had been of ample capacity to do efficient work, the results observed on account of its lack of capacity would not have been noticed.

Effect of Classifier on Capacity

It was observed that when feeding the tube-mill with material 6-mesh and finer, at the rate of 144 tons dry ore per 24 hours, about 8 per cent of the product remained on 100-mesh screen, with about 70 per cent of minus-200. Practically no material was returned from the classifier, so that in effect the tube-mill was producing a finished product as above. In order to maintain the desired density of the pulp flowing from the classifier, it was not practical to send the feed to the classifier, but directly to the tube-mill, using the classifier only to separate and return to the tube-mill the oversize from its product. When the feed was in-

creased substantially to more than 144 tons, oversize began to be returned by the classifier. About 210 tons per 24 hours was the limit of capacity of the classifier, when making a clean separation.

When the tube-mill was fed at the rate of 240 tons per 24 hours, a screen analysis of the classifier overflow showed 15 per cent remaining on 100-mesh screen, with about 56 per cent minus-200; and in the return to the tube-mill from the classifier there was 22 per cent plus-100 and 16 per cent minus-200. This showed that if the classifier had had capacity to separate the oversize from finished product, the 16 per cent of minus-200 which was returned with the oversize to the tube-mill would have passed out with the discharge from the classifier, making a total of 72 per cent minus-200; and if in making this separation 7 per cent of the material under 60-mesh and on 100-mesh had passed out from the classifier with the oversize where it belonged, there would have been left the 8 per cent on 100-mesh in the overflow as in the first case.

Under the first condition, with the classifier practically inoperative and returning no oversize, the tube-mill was making 92 per cent of 144 tons, or 132.48 tons, of minus 100-mesh. In the latter case the tube-mill in connection with the classifier returning oversize, was grinding 92 per cent of 240 tons, or 220.8 tons, of minus 100-mesh product; but the classifier did not do its work properly, as 30 per cent of the material returned to the tube-mill was minus 100-mesh and considerable oversize went off in the overflow from the classifier. Later when the classifier was changed it was found that there was no more plus 100-mesh product made when the tube-mill was grinding at the rate of 240 tons per 24 hours, with a classifier returning the oversize, than there was when it was grinding at the rate of 144 tons per 24 hours with no oversize returned from the classifier. These results would indicate that the efficiency of the tube-mill was decidedly greater when worked in closed circuit, than when it was attempted to deliver a finished product direct from the tube-mill in open circuit.

Results at a later period, when a still larger classifier had been installed, showed that the tube-mill worked even more efficiently when fed at the rate of 288 tons per 24 hours. In fact, every time during this period of three months when we thought we were beginning to reach the capacity of the tube-mill on a certain feed and to produce a certain mesh product, we would find that what we had really determined was the capacity of the classifier used in connection with the tube-mill and not the capacity of the tube-mill itself or of an efficient combination of tube-mill and classifier.

Effect of the Pulp-Load on Efficiency

A recording watt-meter was used in connection with the motor driving the tube-mill, and the observations taken from this record showed that the load of pulp which the tube-mill was carrying had a most decided effect upon the ultimate duty or efficiency of the tube-mill by its effect upon the power necessary to drive it. With a feed at the rate of 144 tons per day containing about 40 per cent moisture, the motor took 75 kilowatts. With a feed at the rate of 240 tons per day containing about 38 per cent moisture, the motor took 62 kilowatts. At another time with a feed of 180 tons per day with 38 per cent moisture, the motor took 70 kilowatts. By reducing the moisture in the tube-mill discharge to 30 per cent, by increasing the amount of material returned from the classifier, thus making a heavier floating load in the tube-mill, the power was reduced to 65 kilowatts. When the tube-mill was fed at the rate of 350 tons per 24 hours, feed containing about 40 per cent moisture, only 55 kilowatts was required to drive it. It would seem clear, therefore, that in making a comparison of the first two conditions, namely, (1) grinding 144 tons of dry ore all from 6-mesh feed to minus 100-mesh product, without any classifying; and (2) grinding 240 tons of dry ore all from 6-mesh feed to minus 100-mesh product with a classifier returning the oversize; it is evident that, not only was the capacity increased by using the classifier in closed circuit with the tube-mill, but the efficiency of the tube-mill was also increased by having a greater floating load, due not only to its ability to handle a larger amount of floating load, but also to a greater floating load from the amount of oversize in the closed circuit. The reduction in power necessary to drive it was from 75 kilowatts to 62 kilowatts.

To emphasize this point: If we assume that power costs 1 cent per kilowatt hour, then the cost for power per ton of ore ground in the first case would be twenty-four hours times 75 cents, amounting to $18.00 for 144 tons of ore, or 12½ cents per ton. In the second case, the cost for power per ton of ore ground would be 24 hours times 62 cents, amounting to $14.88 for 240 tons

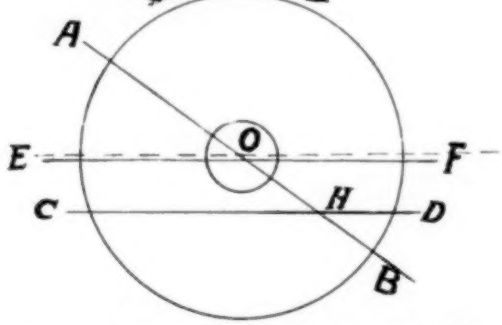


FIG. 1—CROSS-SECTION THROUGH TUBE-MILL

of ore, or 6 2/10 cents per ton. This certainly is one answer to the question as to whether the tube-mill is more efficient when operated with or without a classifier in closed circuit.

The results of my observations over this period of three months on this particular tube-mill, showed plainly that, with a given load, the power decreased very rapidly as the density of the pulp was increased, starting with a density of two parts of water to one part of ore and reducing the amount of water to 30 per cent. This was the greatest density obtained at any time, but there was no indication of congestion or clogging; and with a load at the rate of 240 tons per day, I would have liked to reduce the moisture still further if it had been practical. Of course the adjustable quick discharge attachment had the effect of lowering the discharge opening below the feed opening and increasing the flow of pulp through the tube-mill.

The pebble load is an unbalanced load. The pulp, or the floating load, is a balanced load. Any increase in the weight of the latter, due either to increasing its density or increasing the amount by carrying a greater quantity of material in the circuit, is bound to decrease the power necessary to drive the tube-mill. Referring to Fig. 1, let AB represent approximately the pebble load in action; let CD represent a certain pulp-load level; let EF represent another pulp-load level; let O represent the center of discharge opening. Then the more closely the triangle BHD approaches the triangle BOF in quantity or the triangle AOE in weight, or both, due to increased density, the less will be the power required to drive the mill. The instantaneous effect of changing this factor in the operation of the tube-mill, as shown by the recording watt-meter, was most interesting, and both the mill crew and visitors were much surprised at the results shown.

Chicago Heights, Ill.

The Use of Hydrometallurgical Apparatus in Chemical Engineering

BY JOHN V. N. DORR

(Concluded from page 59 of the January issue)

The Dorr Thickener

The Dorr thickener was developed by me in 1906, when, in remodeling a mill in the Black Hills, I desired to thicken the slime pulp from classification continuously in large units and avoid the use of the large cones which accumulated solid slime on the sides and gave much trouble.

The trial machine was operated in a tank 35 ft. in diameter by 12 ft. deep at a speed of 1/20 r.p.m. and gave excellent results, continuing in operation until the mill burned five years later.

DESCRIPTION

The Dorr continuous thickener consists of a slow-moving mechanism placed in a suitable tank, by means of which the operation of settling may be made continuous through the removal of the settled material to a point of discharge and the prevention of its accumulation as a solid in the tank.

As usually furnished, it consists of a central vertical shaft with radial arms equipped to bring the thickened material to a discharge opening at the center by the slow rotation of the mechanism. The thick material may be discharged by gravity at this point into a launder, or piped to the side of the tank and raised by air lift or pump to the level of the overflow or higher.

The machine is arranged for raising the shaft so that the arms will not be imbedded in the thick material if the power should be shut off for any length of time. The shaft can be lowered again gradually while running. Shaft and gear bracket are supported by a bridge over the tank or suspended from the roof trusses (Fig. 5).

In one case, at the Liberty Bell mill, thickeners have

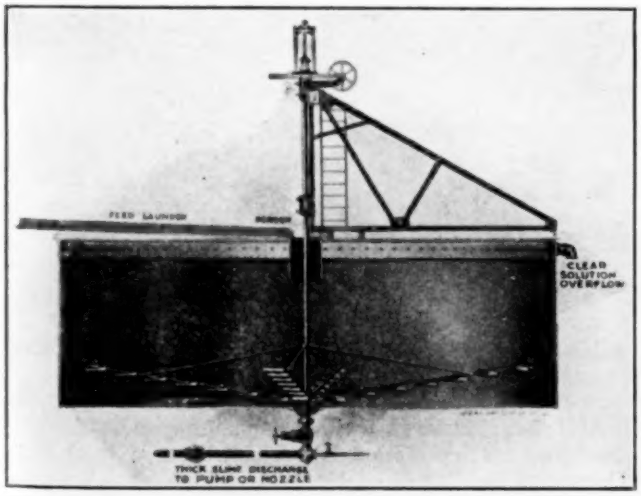


FIG. 5—DORR CONTINUOUS THICKENER

been installed driven from below the tank through a mercury bearing, and proved efficient, although they cannot be raised.

The thin pulp is delivered near the center of the tank in a suitable well with a float to cause minimum disturbance, and the overflow is taken off by a peripheral launder.

The thickened pulp can be accumulated and withdrawn at intervals, or a continuous discharge maintained, as desired. Nozzle discharge is in use in some concentrating mills where a comparatively thin pulp is desired, and also in one case where a product of only 30 per cent moisture is being obtained. Many are using diaphragm pumps for this purpose. They have the advantage of ready regulation and require little attention. Having a positive displacement, they tend to regulate automatically the amount of solids withdrawn, for, when the pulp becomes thicker, more solids are pumped with each stroke. A pet cock to admit air into the suction has proved most satisfactory as a means of regulation.

SPEED

The thickener has been operated at speeds ranging from 1 revolution in 2 minutes to 1 in 40 minutes. A quick-settling sandy material will offer great resistance

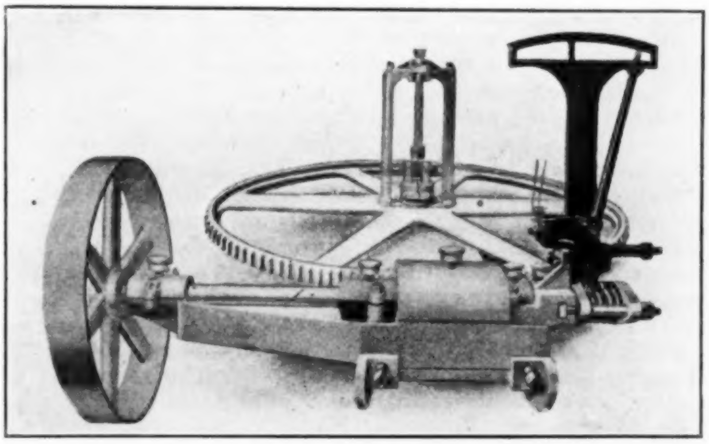


FIG. 6—OVERLOAD ALARM AND RESISTANCE INDICATOR ON DORR THICKENER, WITH ARRANGEMENT FOR RAISING SHAFT WHILE OPERATING

unless a comparatively high speed is maintained, while colloidal slime will give a slightly thicker underflow, at a very slow speed. It will be found when handling sandy material that if the sand accumulates so that it is being moved around the tank by the channel arms as well as being advanced toward the center by the plows the resistance increases rapidly and the speed should be increased.

POWER

This varies with the size of the tank and the nature of the feed. Of course, the motor input is much larger than the actual power consumed, owing to the low load factor commonly used, as it is essential to have power enough to meet an unusual strain. Spring measurements have shown approximately 1/20th hp. being transmitted to the worm shaft of a 44-ft. thickener handling a classified slime. It would not be advisable, however, to install less than a 1-hp. motor on a single machine, but ½ hp. each can be allowed when several are driven from one lineshaft.

REPAIRS

Normal operation of the thickener causes no wear except on the worm, and many machines are running to-day that have not cost a cent for several years. On the other hand, if started after a shutdown without raising, a strain of any amount may be given so that the "weakest point" would have to yield.

The overload alarm, Fig. 6, is arranged to indicate the resistance offered by the mechanism as shown by the thrust on the worm shaft and to ring an alarm when the load becomes excessive. A solenoid or other means can be used to correct automatically the condition causing the excessive load, by reducing the feed or

increasing the underflow. The alarm has proved very valuable, especially on quick-settling pulp, when it is desired to obtain the thickest discharge.

LABOR

The attendance required varies with the regularity of conditions maintained and is usually confined to lubrication once a shift, so that the care of the thickeners is included in the duties of some man employed principally on other work.

CAPACITY

The capacity of Dorr thickeners on any pulp has been found to be primarily a function of area, although the depth of the tank has an influence depending on the dilution of the feed and the dilution of the underflow desired. With a given area and depth and a very dilute feed and underflow the capacity depends on the amount of liquid that can be clarified; i.e., additional solids, but no additional liquid, can be added to a tank already fed to capacity without overflowing slime. On the other hand, with a feed perhaps 8 of liquid to 1 of solids and a thick discharge of 2 to 1 or less, it will be found usually that additional liquid can be added to a thickener operating at capacity without overloading it, but any addition of solids will cause slime to overflow.

If a plant requires more settling capacity, raising the temperature of the solutions may prove an economical way to add 10 to 20 per cent. The capacity of any filter can also be increased by this means.

Table II represents data given me from time to time. It shows the settling area in use per ton in different mills which in many cases were not feeding their thickeners at capacity.

TABLE II—OPERATING DATA ON DORR THICKENERS

Mill	Sq. Ft. Settling Area per Ton of Solids Thickened per 24 Hr.	Sq. Ft. Settling Area per Gallon Overflowed per Minute	Remarks
San Rafael, Mexico	4.5	....	Tube-mill product, 75 per cent. — 200 mesh, discharge 45.5 per cent. solids.
Liberty Bell, Colorado.	15.0	12.6	Tube-mill product, much light argillaceous slime. Discharge 33 per cent. solids: + 100, 17 per cent.; + 200, 13 per cent.; — 200, 70 per cent. Feed 9:1. Solution fed at capacity; solids not. Large area per gallon overflowed per minute due to density of underflow and nature of the slime.
Mogul, South Dakota.	3.92	....	Tube-mill product; ore siliceous: + 60, 0.6 per cent.; + 100, 7.8 per cent.; + 200, 26 per cent.; — 200, 65.6 per cent. Discharge 56 to 59 per cent. solids. Continuous decantation.
Batopilas, Mexico.	0.6 to 0.9	....	40-mesh product; 90 per cent. passing 100 mesh.
Zambona, Mexico	3.1	....	Tube-mill product. Discharge 40 per cent. solids.
Dominion, Ontario	5.4	....	Tube-mill product, 88 per cent. — 200 mesh, ore diabase. Discharge 40 per cent. solids. Feed 6:1.
Porcupine-Crown, Ontario.	4.25	....	Tube-mill product, 75 per cent. — 200 mesh. Discharge 65 per cent. solids. Quartz ore. Continuous decantation. With 5.1 sq. ft. settling area per ton settles to 71 to 73 per cent. solids.
El Palmarito, Mexico.	4.5	....	Tube-mill product: pure quartzite, 97 per cent. — 200 mesh. Feed 7:1. Discharg 65 to 70 per cent. solids. Continuous decantation.
Amparo, Jalisco, Mex.	4.9	1.4	Tube-mill product, siliceous: 93.5 per cent. — 200 mesh. Feed 24.5:1. Discharge 23.5 per cent. solids: used to feed vanners.
Veta Colorado, Parral, Mex.	5.0	3½*	Tube-mill product, rather argillaceous: 71 per cent. — 200 mesh. Feed 11:1. Discharge 33 per cent. solids for agitator Have settled to 65 per cent. solids.
Smuggler-Union, Telluride, Colo.	....	....	Very clayey slime with classified sand. Screen test: + 40, 1.48 per cent.; + 60, 7.27 per cent.; + 100, 14.81 per cent.; + 200, 11.63 per cent.; — 200, 65.81 per cent.
	30.0	26.0	Settling from cold water, slightly alkaline. Feed 8:1. Discharge 50 per cent. solids, 1.429 sp. gr.
	10.0	....	Settling from cyanide solution. Feed, 2.5:1. Discharge 40 per cent. solids, 1.316 sp. gr.
A large copper company, Arizona.	11.6	8.11	Considerable argillaceous slime. Feed 10.4 per cent. solids. Discharge 25.3 per cent. solids.
Pennsylvania Steel, Lebanon, Pa.	14.2	2.48	Thickening ahead of vanner concentration. Feed 2.8 per cent. solids. Discharge 10.6 per cent. solids. Overflow 0.4 per cent. solids, extremely fine, which does not interfere with using water again.
Nevada Consolidated, Ely, Nev.	....	1.25	"Each 17-ft. thickener supplies wash water for 20 Wilfley tables and occasionally for wash on vanners. One thickener has a greater capacity than twelve 8-ft. cones." Area of 17-ft. tank is 226 sq. ft.; of the twelve 8-ft. cones, 525 sq. ft.
Broken Hill, Proprietory, Australia.	....	1.80	Dewatering slime from lead-zinc concentration mill. Feed 100:1. Dischrage 55 per cent. solids.
Anaconda Copper, Mont.	....	5.95	Dewatering slime from concentrator. Forty 4-deck thickeners, each 28 ft. in diameter by 3 ft. 3 in. deep, handle about 26,000,000 gal. of pulp per day which contains approximately 2 per cent. solids. A clear overflow obtained, the underflow containing about 15 per cent. solids, which is fed to buddles.

The data given here show that when pulp is carried in cyanide solution a provision of 5 to 6 sq. ft. per ton for a siliceous tube mill product is ample and from 7 to 15 sq. ft. for a clayey material or classified slime product. When very dilute products are handled the area required is determined usually by the gallons per minute to be overflowed.

*Not up to capacity of overflow.

DENSITY OF UNDERFLOW

This depends on the nature of the pulp to be settled and the size of the particles. An argillaceous pulp, such as that at the Liberty Bell in Colorado, although containing a large percentage of reground siliceous material, will not settle thicker than 60 per cent moisture, while a finely ground quartz will give as low as 27 per cent moisture. At the Porcupine-Crown plant, handling a quartz product of 75 per cent minus 200 mesh, the average final pulp discharged contains 30 per cent moisture with the feed at the rate of 1 ton of solids per day for each 4.7 sq. ft. of tank area.

We have no reason to think that the use of the Dorr thickener will increase the amount of water that can be clarified in a given settling area at the beginning of the flow into the tank, but the removal of the pulp as rapidly as it settles certainly avoids the decrease in the settling rate which would follow when a tank is filling up in intermittent settling.

At one plant where reground ore pulp was thickened from 10 to 1 to approximately 2 to 1, actual experience indicated that the change from intermittent to continuous settling enabled three tanks equipped with Dorr thickeners to do the work of five used intermittently.

THE DORR TRAY THICKENER

The original thickener was installed in a tank 12 ft. deep and we adhered to approximately that depth, varying from 6 to 16 or 20 ft., for a number of years. One reason for this was that it early showed itself to be an advantage to have ample storage capacity for thickened slime at the bottom of the tank. It not infrequently happens that the flow of slime to the settling tank will vary during the day and the settling qualities of the slime may vary as well so that if the feed is light a large quantity of clear liquid accumulates on the top of the thickener, which when more slime comes, flows away, together with the freshly clarified water and partly thickened slime takes its place, thus giving a great reserve capacity.

In 1913, however, I had occasion to go into the question of securing large settling capacity with small floor space and developed what I have called a tray thickener. There are two types of this. The first, which would seem to be the simplest, has been installed by the Anaconda Copper Company and in the Coeur d'Alenes. It consists of two or more shallow tanks, each carrying thickening apparatus attached to a common shaft and acting as independent units with its own feed, clear water overflow and thick slime discharge. Tests made by the Anaconda Copper Company indicated that with their material tanks 28 ft. x 3 ft. would handle approximately 90 per cent of the material, that tanks 28 ft. x 9 ft. would handle so that this gives them a great economy in plant construction.

Fig. 7 shows this type and represents one of forty

tray thickeners installed in their settling plant, which is handling 26,000,000 gal. of water a day and separating therefrom 2500 tons of extremely colloidal slimes. Each tray is a separate unit, with its own feed, thickened discharge and clear outflow.

The second type of tray thickener, which I have called the submerged type (Fig. 8) was tested first at the Homestake Mill at Lead, South Dakota, and consisted as tried there essentially of a shallow thickener and tank entirely submerged in a cone-bottom settling tank. The space below the small thickener had its own feed and discharge and the clear water overflowing from it joined the overflow of the shallow thickener tank. The latter has its own feed and discharge as well.

Fig. 9 gives the result of tests made there to show comparative capacities of tanks with and without the tray. Applying the idea to thickeners already installed, Fig. 9 shows the installation of a tray in a standard deep thickener. It gives in effect two tanks, each with its own feed and discharge, and a combined overflow, and in practice has resulted in enabling us to add 70 to 100 per cent to the capacity of plants already in operation. It has been found unnecessary to make this tray strong enough to support these tanks filled with liquid if the space below it is empty, as by means of an automatic float we have arranged to make connections between the upper tank and the lower in case the level of the liquid drops in either. It will be evident, I think, that these trays will afford means of obtaining a large amount of settling capacity with comparatively small floor space, and we are working now on their further development.

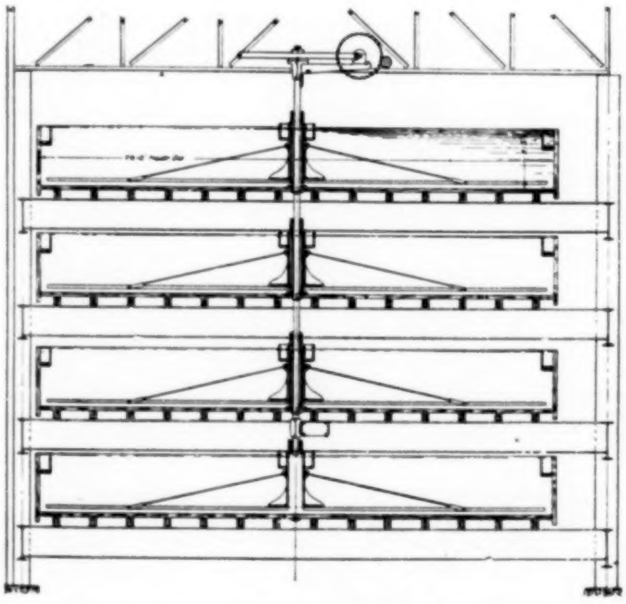


FIG. 7—THE DORR TRAY THICKENER, SUPERPOSED TYPE

LARGE THICKENERS

For a long time the largest thickeners in use were in tanks 50 ft. in diameter by 20 ft. deep, at the Nevada Consolidated Company. Within the last year, however, the Arizona Copper Company has installed a Dorr thickener in a tank 130 ft. in diameter. Fig. 10 shows the machine in operation. It has proven entirely successful and indicates the possibility of furnishing very large unts which will cost less per square foot of settling area than the smaller ones. The tank in this case is merely a ring of concrete erected on a slag dump, the settled slime forming its own bottom. It is probably as large as any we would care to build, but we anticipate building up to 100 ft., using the bridge and central shaft, which we now use on our standard machine.

This large thickener has handled over 1200 tons of solids and Mr. David Cole, the company's engineer who designed and installed it, estimates that it would take care of 2000 tons of material 40 mesh and finer. Its overflow has been over 3,000,000 gal. per day, and its limit of capacity has not yet been reached. The net saving in water by the use of this machine with the mill at capacity is $120 per day.

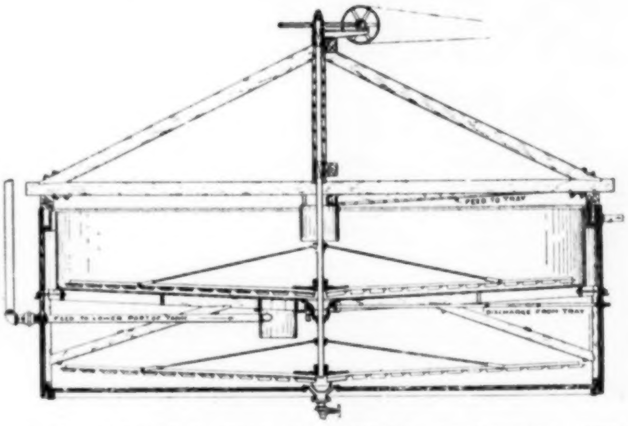


FIG. 8—THE DORR TRAY THICKENER, SUBMERGED TYPE

It has proved feasible under some conditions to install a Dorr thickener in a rectangular settling tank and get good results.

USES

The thickener was originally introduced in cyaniding for thickening slime or reground pulp previous to agitation and filtration, and came into general use for that purpose. Within the last few years it has proved a means for recovering the dissolved value as well by continuous counter-current decantation, which will be spoken of later. Its use in thickening ahead of slime concentration has become very general, nearly all the large copper and lead companies having adopted it within the last few years.

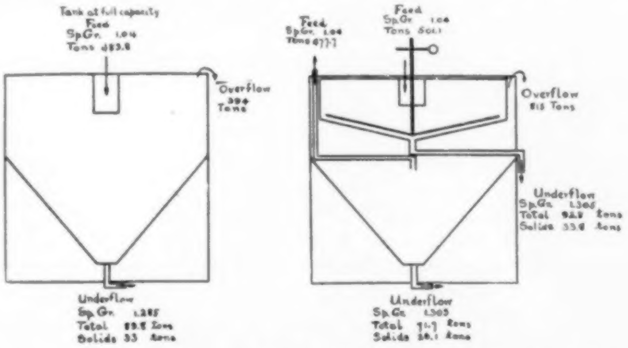


FIG. 9—TEST OF DORR TRAY THICKENER AT HOMESTAKE MILL, LEAD, S. D.

The development of flotation concentration has opened a new field for the thickener, the machine being used in most of the plants in this country and in Australia for dewatering both ahead of the flotation boxes and, in some cases, after them as well, also for collecting the concentrates and recovering warm water from the tails for reuse.

INDUSTRIAL USES

The thickener presents great opportunities for the recovery at an extremely small expense of all kinds of

finely divided residues that go to waste or are recovered intermittently from settling ponds. The expense, including interest on equipment, amounts in one case to 1 mill and in another 2 mills per 1000 gal. clarified. In both cases the solids removed were colloidal ore slimes. One plant recovering a finely divided organic material from settling ponds substituted the Dorr thickeners for them and I am advised saved the labor of 12 men per day. Its use for removing heavy silt in water purification seems possible with the large units now feasible.

Sewage treatment and its use for the prevention of stream pollution looks promising. A plant is now planned for the recovery of precipitated ferric-hydrate from mine water.

In all industrial work its use to furnish a much thicker product to a filter press will mean great increase in the capacity of the press with diminished costs.

CONTINUOUS COUNTER-CURRENT DECANTATION

Continuous counter-current decantation consists of the operation of a series of settling vessels in such a way that the solids to be treated continuously pass through them in succession, being diluted after each thickening by solution from the overflows passing in the opposite direction.

The objects to be attained are the dissolution under most favorable conditions of a portion of the solids, the separation of a solution from a finely divided solid with minimum dilution, or both combined.

The last result is that usually obtained in metallurgical work, as the separation of most of the dissolved material from the solids always occurs, and even when apparently adequate means for dissolution are provided ahead of the system the favorable conditions afforded usually give an additional extraction.

HISTORY

I will not take time to go into detail as to the history of continuous counter-current decantation, but simply say that the principles are very old and have been applied in many ways in chemical technology as well as in metallurgy.

The first cyanide plant using this method in the United States was erected by John Randall in the Black Hills in 1902, using large cones for settlers, and was operated for a year. The invention of the Dorr thickener in 1906 gave an opportunity to avoid the troubles inherent in cones, and in 1910 the first modern plant was started. Since that time there have been a large number of plants installed, several of them replacing vacuum filters, so that it may be regarded to-day as one of the well-established methods of cyaniding. Several years ago Dr. R. Gahl successfully operated an experimental plant with cone settlers, leaching copper ore slimes with sulphuric acid, treating seven or eight tons daily, to which he refers in a paper* read before the American Electrochemical Society. A test plant of 75 tons capacity is now starting, using thickeners.

The following description of a typical flow sheet of a continuous counter-current decantation cyanide plant will undoubtedly explain the process further, and also show the method we have used to determine the results that may be expected from any conditions assumed.

The square marked Mill, in Fig. 12, represents the grinding machinery, and we assume the ore is crushed in cyanide solution which brings the fine pulp continuously into thickener V, whence the solids pass through the agitators and thickeners W, X, Y and Z until discharged from Z as tailings.

*Transactions American Electrochemical Society, vol. XXV, page 243 (1914).

All the figures on the flow sheet refer to tonnages of liquid per day.

The following conditions are assumed:

1st. The thick pulp underflows are thoroughly mixed with the clear overflows before entering the next tank, so that the dissolved gold is uniformly distributed through the liquid.

2nd. 100 tons of ore are milled per day.

3rd. \$8.00 is dissolved per ton; 75 per cent in the mill, the balance in the agitators.

4th. The pulp from all thickeners is discharged at a ratio of 1:1 or 50 per cent moisture.

5th. 300 tons of solution is precipitated to a value of \$0.02 per ton.

To determine the value of the solution from any thickener, if V, W, X, Y and Z equal the value in dollars per ton of the solution leaving each thickener, we get the following equations, as the same amount of gold and solution will enter and leave each tank:

(1) $400W + (\$6.00 \times 100) = 300V + 100V$.

That is, the gold in W, plus the additional gold assumed to be dissolved in the mill, equals the overflow and underflow of V.

(2) $100V + (\$2.00 \times 100) + 400X = 400W + 100W$.

The $(\$2.00 \times 100)$ represents additional gold dissolved in the agitators.

(3) $100W + 400Y = 400X + 100X$.

(4) $100X + 100Z + (300 \times \$0.02) = 400Y + 100Y$.

(5) $100Y + 100$ water (no value) $= 100Z + 100Z$.

In No. 4 the \$0.02 represents the value of the precipitated solution returned to Y.

No. 5, representing a simple dilution with water, means that Z will have one-half the value of Y.

Solving these equations, we get the following values: $V = 2.656$, $W = 1.156$, $X = 0.286$, $Y = 0.076$, $Z = 0.038$, which may be checked as follows:

The gold precipitated.	($2.656 — $0.02) × 300 =	$796.80
Lost in tailings.............	($0.038 × 100) =	3.80
Total	=	$800.60
Total assumed dissolved.......	(10 × $8.00) =	800.00
Discrepancy due to decimals...........		.60

From the above we deduce:

Assay value of solution precipitated........ =	$2.656
Dissolved loss per ton solution.............	.038
Dissolved loss per ton ore.................	.038
Percentage dissolved gold recovered........	99.6

Similar calculations have shown that if one thickener is omitted from the flow sheet and no other conditions are changed the dissolved loss is increased to \$0.133. Using the same four thickeners and precipitating 400 tons, instead of 300, the loss is cut to \$0.08, while if the pulp can be discharged with 60 tons of solution, instead of 100, making it contain 37 per cent moisture, the amount precipitated can be reduced to 240 tons and the loss will only be \$0.76 per ton of ore, although the solution precipitated will assay \$3.321.

I should explain here that the reason the precipitated solution is added at Y, instead of Z, where it would obviously be more effective in increasing the extraction of gold, is that we have also a mechanical loss of cyanide to contend with. The 100 tons of water which can be added at Z to replace the liquid discharged with the tails reduces the strength of the solution lost to one-half when added to 100 tons of cyanide solution, whereas if added to 400 tons of solution it would reduce it only to four-fifths. A further saving in cyanide can be made by adding the barren solution at X, but this usually means adding an additional thickener on account of excessive gold losses.

It will be noted from these figures that the loss in gold can be regulated at will by increasing the solution

precipitated or the number of thickeners in the series, and also that pulp settling to 30-40 per cent moisture can be treated much more efficiently than pulp settling to 50-60 per cent. If pulp cannot be settled to 50 per cent or thicker it will usually be profitable to use a filter merely for dewatering at the end of the series.

DETAILS OF PLANT

The flow sheet shown, with what has already been said about Dorr thickeners, will give a clear idea of the construction of a continuous counter-current decantation plant.

The tanks in the series are either arranged on a level, in which case both the overflow and underflow must be elevated before being transferred into the next tank or in a series of steps so that the overflow goes by gravity from tank to tank, and only the smaller quantity of underflow is raised each time. Each method has its advantages.

The transfer of pulp is preferably done by a diaphragm or other pump of fixed displacement, as thereby a certain amount of automatic regulation is obtained.

Storage Tanks.—The more a flow sheet and the actual conditions of mill operations are studied the less additional storage capacity is felt necessary.

RESULTS

I realize that details of the technical results obtained in cyaniding will not be of great interest to chemical engineers, so will only say that when working on a hard, quick-settling ore ground to pass an 80-mesh assayer's screen or finer, which can be settled to a thick product containing 35 per cent to 50 per cent moisture, it has proved a most efficient means for the recovery of dissolved gold and silver from the pulp.

Compared with the usual filtration methods it has shown lower operating costs in spite of a higher mechanical loss in cyanide, and a higher recovery due to a lower loss of dissolved values and often to an additional extraction being made that could not be made commercially by direct agitation.

The following quotation from an article on "Continuous Counter-Current Decantation" in the *Engineering and Mining Journal* of October 31, 1914, sums up the conclusions reached at the Gold Road Mill, where continuous counter-current decantation was installed to replace a vacuum plant:

"The operators state that the principal disadvantage they found with the vacuum-filtration system upon their ores was that it was almost impossible to wash satisfactorily the cakes on the leaves. Cakes of uniform resistance could not be formed. They would crack badly and large sections would fall from them, making satisfactory washing impossible. Besides, the expense of labor, repairs and power is considerably more than is necessary in following the counter-current decantation system. They find practically no difference between the two systems in the amount of cyanide and lime consumed, perhaps a slightly greater quantity, amounting to about 0.1 lb. of cyanide, is being consumed in the decantation system.

"An advantage found with counter-current decantation is that the dissolution of gold is so perfect, due to the longer contact between the solutions and the pulp. The difference, considering all things, between leaf filtration and counter-current decantation, is at least 60 cents per ton of ore treated in favor of the latter."

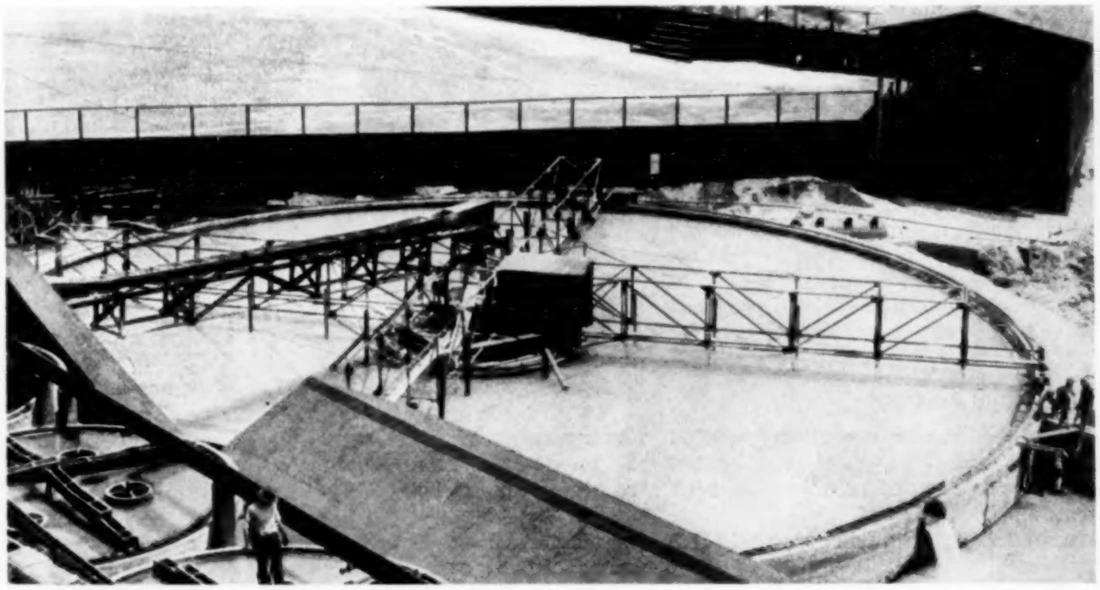


FIG. 10—DORR THICKENER INSTALLED IN A 130-FOOT DIAMETER TANK BY THE ARIZONA COPPER COMPANY

This figure is higher than could be expected under usual conditions, but we have had definite statements of savings from the other plants that have changed as well. Information I have received from a number of plants operating indicate that on quick-settling ore from which $5.00 to $20.00 is recovered the mechanical loss in gold varies between 4 and 10 cents per ton of ore.

GENERAL CONSIDERATIONS—DISSOLUTION AND RECOVERY

From the nature of the process it is apparent that its use for dissolution is antagonistic to its use for recovery of the dissolved material, and although some have proposed the alternation of agitators and thickeners, I have always advocated where a high per cent of recovery in a concentrated form was required, as in cyaniding, all dissolution possible should be made ahead of the system. In other cases, as that described by Dr. Gahl, where it was essential to make the dissolution in stages so as to end with a nearly neutralized liquid and have the copper pulp when nearly finished meet fresh acid, it is, of course, essential, but calls for one series on dissolution and another on washing.

SCALE OF OPERATIONS

It will be seen that any continuous method of treatment of materials has greater relative advantages with an increase in size of operations and a continuous counter-current decantation plant with 50-ft. tanks will require no more labor, and, in fact, less than one with 10-ft. tanks, although it will have 25 times the capacity. As the actual labor cost for operating a series of thickeners is less than one man a shift, it will be seen that

if any washing or leaching operation is requiring the full time of one or more men this method can be considered if other conditions are favorable.

OTHER APPLICATIONS

Fig. 12 is intended to show a copper problem which I think will correspond to many problems that may occur in chemical industries, namely, the complete washing of finely suspended solids and the obtaining of the dissolved material in as concentrated a form as possible from which it is to be recovered by evaporation or complete precipitation, or by any other method, so that none of the liquid has to be returned to the system, as in cyaniding.

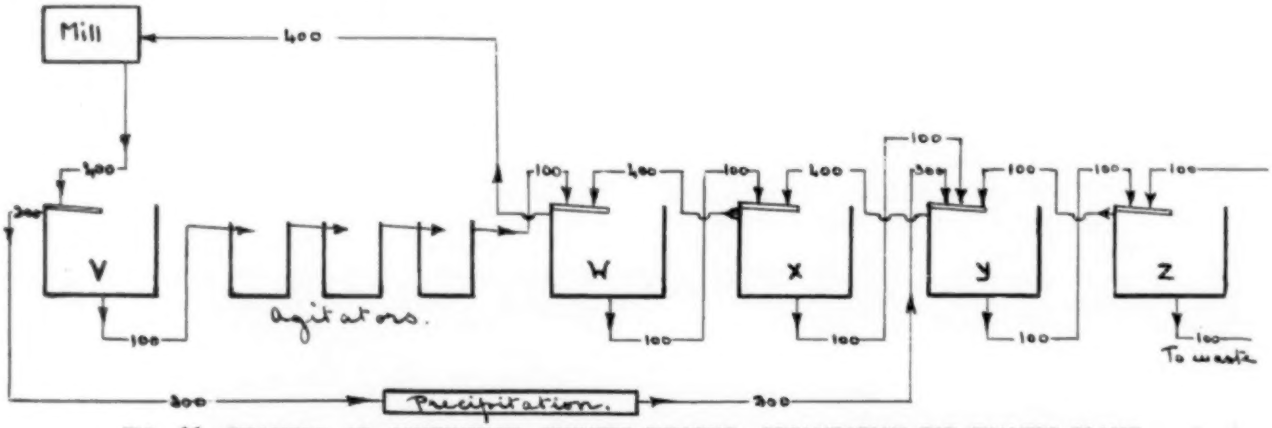


FIG. 11—EXAMPLE OF CONTINUOUS COUNTER-CURRENT DECANTATION FOR CYANIDE PLANT

CONDITIONS ASSUMED

(*a*) 100 tons of oxidized copper ore slimes treated per day.

(*b*) Slimes contain 2 per cent of soluble copper or 40 lbs. of copper per ton.

(*c*) Pulp is discharged from all thickeners with 41.2 per cent moisture.

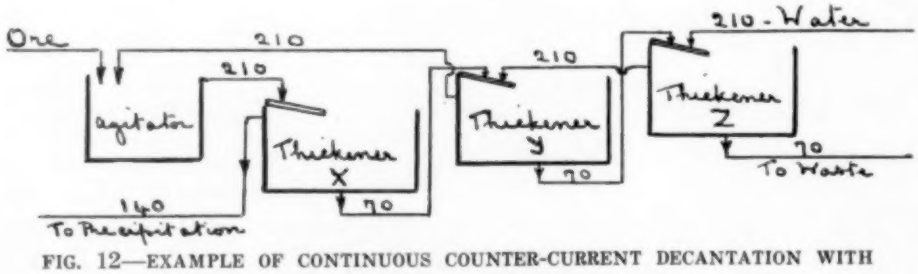


FIG. 12—EXAMPLE OF CONTINUOUS COUNTER-CURRENT DECANTATION WITH WASHING LIQUID NOT REUSED

Figures in Fig. 12 refer to solution tonnages.

(*d*) Inflow to each thickener is thoroughly mixed before entering same.

(*e*) 210 tons of wash water added to thickener "Z." The total overflow from thickener "X," 140 tons, sent to precipitation, and 70 tons sent to waste with the discharged residues from thickener "Z."

(*f*) Let X, Y and Z represent the pounds of copper per ton of solution discharged from the respective thickeners.

If we equate the inflow and outflow of each thickener in terms of tonnage and copper contents we have:

(1) $70X + 140X = 210Y + (100 \times 40)$ pounds
(2) $70Y + 210Y = 70X + 210Z$
(3) $70Z + 210Z = 70Y + 210$ tons of water.

Simplifying and solving we obtain:

$X = 27.5132$ lbs. copper per ton of solution.
$Y = 8.4656$ lbs. copper per ton of solution.
$Z = 2.7164$ lbs. copper per ton of solution.

From the above the following results are deduced:

1. Overflow to be precipitated, *i.e.*, X, contains 1.37 per cent copper, or 27.5 lbs. per ton of solution.
2. Solution wasted with the residues, *i.e.*, Z, contains 0.13 per cent copper, or 2.7 lbs. per ton of solution.
3. Copper sent to precipitation = 96.3 per cent of that dissolved.
4. Pounds of copper lost per ton of slimes = 1.48 lbs.

Varying the number of thickeners used and solution tonnage sent to precipitation, and assuming conditions *a*, *b*, *c* and *d* remain constant, we obtain the following results given in Table III.

It is apparent from this that the enriched solutions, which contain 96.3 per cent of the soluble copper, will carry 1.37 per cent copper per ton, and that you get no weak liquors at all for further handling. The additional tabulations show the results of changing various factors. You will see from this that precipitating 140 tons of solution, but adding a fourth thickener, increases the percentage recovered from 96.3 per cent to 98.8 per cent, with an enrichment of the solution from 1.37 per cent to 1.41 per cent. Precipitating 210 tons of solution, on the other hand, shows a solution to be precipitated carrying 0.93 per cent copper with three thickeners and 0.94 per cent with four thickeners, while the percentage of recovery is 98.5 per cent and 99.6 per cent. In other words, it is easy to see that by using the proper number of thickeners you can make practically any recovery desired and get any concentration you wish.

This method could be applied as readily to the manufacture of caustic from soda ash and lime, and I can say that a plant to use it to some extent has been purchased abroad, but its installation has been delayed by

TABLE III

Number of thickeners used	3		4		3		4	
Tons of solution sent to precipitation	140		140		210		210	
	Lbs. per ton.	Per cent.	Lbs. per ton.	Per cent.	Lbs. per ton.	Per cent.	Lbs. per ton.	Per cent.
Copper in the solution for precipitation	27.5	1.37	28.2	1.41	18.7	0.93	18.0	0.94
Copper in the solution wasted with the residues	2.7	0.13	0.7	0.03	0.9	0.04	0.2	0.01
Lbs. of dissolved copper lost per ton of slimes	1.48		0.49		0.63		0.16	
Per cent. of dissolved copper sent to precipitation	96.3		98.8		98.5		99.6	

the war. As the reaction between the soda and the lime requires a definite time it is possible that it might be necessary to do it in charges, but the same was believed true in cyaniding until it was demonstrated that continuous agitation with a series of agitators was better.

THE DORR AGITATOR

This machine, Fig. 13, was designed by me in 1910, but did not come into actual use until 1912, when about a half dozen machines were put out for trial purposes on a working scale at several different plants. The results obtained were so good that last year many more were installed in this country and abroad. During 1914, although mining in general has been very quiet, the use of them has increased greatly and from all installations made we have had nothing but satisfactory reports.

The illustration will give a good idea of the machine, which is very much like the Dorr thickener, the central shaft being replaced by a pipe, at the top of which distributing launders are arranged to distribute the pulp, which is raised through the pipe by means of air.

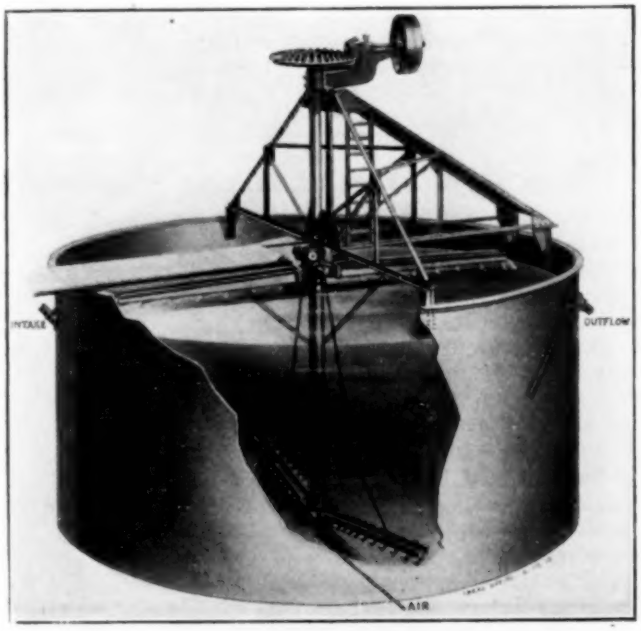


FIG. 13—DORR AGITATOR

A worm and sheaves provide means for raising or lowering the hinged arms at will.

In cyanide metallurgy mechanical sweeps in flat-bottomed tanks were first used for agitating the pulp, but the great difficulty experienced in most cases with these, including breakages and the power required, made the use of a high cone tank with a central air lift seem most attractive, and when it was introduced into this country and Mexico from Australia a very large percentage of the mills installed it.

At this time agitation was done in charges, but when continuous agitation became the established practice a few years ago it was found that there was a great tendency for the coarser material in the pulp being agitated to build up on the sides of the 60° cones used so that eventually the major portion of the agitating area became filled up with solids and the agitation only took place in a small cylinder in the center. It was also found necessary to give a much more violent agitation than the chemical treatment of the ore required in order to keep the pulp in suspension as much as possible.

The Dorr agitator, by the use of mechanical arms with the thickener plows on, which prevents settling of solids and brings the material from the bottom to the central uplift pipe, allows the regulation of the intensity of the agitation given to suit the chemical need of the ore and not the necessity for keeping everything in suspension.

EFFICIENCY

The value of an agitator depends on the cost of making the maximum economic extraction by its use. This will be determined by its cost of agitation per ton per hour and the time required to obtain dissolution.

All the data I have been able to obtain indicate that the cost of agitation per hour is extremely low. Extraction tests that have been made indicate that the rate of dissolution on both gold and silver ores in Dorr agitators, with a uniform although less violent agitation, is at least as rapid as in any other agitators with which it has been compared.

The most favorable conditions for the dissolution of gold and silver in cyanide solution vary with each ore treated. The maintenance of an excess of dissolved oxygen throughout the whole mass of pulp and the free movement of all particles of solids in the liquid immediately adjacent seem to be the only conditions that can be generally specified.

Definite work both in milling and the laboratory indicate that many ores will give a more rapid extraction and allow the use of a weaker solution when agitated as a dilute pulp of 3 to 1 or 4 to 1, and also cause less chemical consumption of cyanide.

The Dorr agitator, with its combination of air and mechanical agitation, gives a flexibility that is apparent, and it insures keeping all the solids in suspension all the time, whether the pulp is subjected to a gentle or a violent movement. This is essential especially in continuous agitation.

SELECTIVE AGITATION

The question of selective agitation was discussed by Mark R. Lamb.* As used here the expression is taken to mean continuous agitation under conditions which cause the coarser particles of the ore to remain in the agitator longer than the average time of treatment and thus give them the longer exposure they may require to obtain the best extraction.

This can be accomplished readily with the Dorr agitator by agitating at a dilution which allows the coarser material to classify out and discharging the raised pulp near the center while the outflow is taken from near the periphery. It will be seen that if a segregation takes place and the agitator is fed a pulp carrying 10 per cent plus 100 mesh, the discharge mav be only 5 per cent plus 100 mesh at first. With twice as much inflow as outflow of 100-mesh material it will concentrate in the agitator while gradually increasing in the outflow until an equilibrium may be reached in which the feed and discharge will both be 10 per cent, and the average pulp in the tank 20 per cent, so that the exposure of coarse sand would be approximately double the average. While this is theoretical, enough work has been done to indicate that the idea can be put to practical use.

Dorr agitators have been installed in tanks of various sizes, the largest being those in use at the Desert Mill at Tonopah, Nevada, in tanks 36 ft. in diameter by 20 ft. deep. The company estimates that the total power required to operate one of these large machines, including mechanical horse power and the air required for maintaining agitation, is not over 5 hp., so you will see that it is extremely small. A recent measurement in a 20-ft. by 12-ft. agitator showed that 10 cu. ft.

*Transactions, American Institute Mining Engineers, vol. XL, p. 775 (1909).

of free air at 15 lb. pressure was all that was needed.

The application of Dorr agitators in the chemical industry has not been investigated to any extent, but it would seem that with finely divided materials from which it is desired to dissolve one constituent that they should perform as useful a function as they are now doing in metallurgy.

ACID-PROOF MACHINERY

As all the submerged portions of classifiers, thickeners and agitators have no reciprocal motion, it has not been found difficult to manufacture them so as to resist ordinary acid liquors and acid-proof machines of all three kinds are now in use.

Metal Production Statistics for 1914

The United States Geological Survey has issued preliminary reports on metal production during the past year. The figures are based on exact records for eleven months with careful estimates for December, and are considered very close approximations to the exact figures. From these reports we abstract the salient features.

Iron.—The quantity of iron ore mined in the United States in 1914 is estimated as between 41,000,000 and 42,500,000 long tons. In 1913 there was mined 61,980,-437 long tons. The Lake Superior district is estimated to have shown a decrease in production of about 37 per cent, and a production of about 32,915,000 long tons. Prices generally were about 50 to 75 cents per ton lower than in 1913.

Gold.—This industry was prosperous in 1914, and the production is estimated to be about $4,000,000 greater than in 1913, totalling $92,823,500. Alaska output increased about $300,000, and Arizona showed an increase of about $500,000. In California the increase was nearly $700,000 more than in the previous year. The greatest increase was shown in Colorado, amounting to over $1,500,000, coming chiefly from Cripple Creek. Nevada, Idaho and Utah showed small decreases. The rank of the principal gold producing states was California, Colorado, Alaska, Nevada and South Dakota, as in 1913.

Silver.—All records for production of this metal would have been broken in 1914 but for the European war. As it was, the figures indicate an output of 67,929,700 ounces, valued at $37,225,000. Notable increases in production were made in Idaho, California and Arizona; decreases were noted in Montana, Utah, Nevada and Colorado. Nevada, however, still retains first place among silver producers, with Idaho, Montana, Utah and Colorado following in the order given. The general average price for the year was 54.8 cents per ounce, the lowest since 1911.

Copper.—The production of this metal will show a marked decrease compared with that of 1913, due to curtailment inaugurated in August and prevailing throughout the balance of the year. The output of blister and lake copper is estimated at 1,129,000,000 pounds in 1914 as compared with 1,224,484,000 pounds in 1913. Refined copper from foreign and domestic sources is estimated at 1,493,000,000 pounds as against 1,615,067,000 pounds in 1913. The average price for the year was about 13.5 cents per pound, being about 2 cents below the 1913 average. Arizona continued in first place among copper producing states.

Lead.—The production of this metal showed an increase of nearly 100,000 tons over the production of any previous year, and at the same time the average price for the year was the lowest since 1898. The estimated output was 537,079 short tons, worth at the average New York price $41,892,162, compared with 462,460 tons in 1913, worth $40,696,480. For the first time in years there were exports of domestic lead to Europe, the total for the year being estimated at 62,924 short tons, valued at about $4,804,000. The average New York price for the year 1914 was 3.9 cents a pound, compared with 4.4 cents in 1913 and 4.5 cents in 1912.

Tungsten.—The production of tungsten ores is estimated as equivalent to about 990 short tons containing 60 per cent WO_3. This is the smallest output since 1908; in 1913 the production was equivalent to 1537 tons. The production from Boulder county, Colorado, in 1914 was only 466 tons as compared with 953 tons in 1913. Prices ranged from $6.50 to $9 per unit (20 lb.) of WO_3. Of the various tungsten minerals, scheelite was produced in largest quantity, mainly from the Atolia district in the Mohave desert, Calif. Utah, Arizona, Idaho and New Mexico produced small quantities of ore.

Arsenic was produced only as a by-product from lead and copper smelting, but the output was the largest in the history of this country, amounting to 4227 short tons of arsenous oxide, or white arsenic. The 1913 production was only 2513 tons. The chief uses of this product are in glass making, for insecticides, and for killing weeds along railroad tracks.

Portland Cement.—The 1914 output of this material was approximately 88,514,000 barrels, compared with 92,097,131 barrels in 1913. The average value per barrel was probably slightly lower than in 1913.

American Institute of Mining Engineers

The annual meeting of the American Institute of Mining Engineers will be held in the Engineering Societies Building, 29 West 39th Street, New York City, from Monday, February 15th, to and including Wednesday, February 17th.

On Monday, February 15th, at 10 a. m. a meeting will be held on safety and sanitation in mining. In the afternoon two sessions will be held at 2 p. m. in different rooms, one on iron and steel metallurgy, the other on non-metallic minerals (clay, potash, etc.)

On Tuesday, February 16th, at 10 a. m. the annual business meeting will be held, followed by a technical session on various mining, metallurgical, and geological subjects. At 2 p. m. a session on fuels will be held by the committees on petroleum and gas and on coal and coke.

On Wednesday, February 17th, at 10 a. m., a session of non-ferrous metallurgy will be held, and at 2 p. m. a session on electricity in mines and mining.

The annual dinner will be held at the Hotel Astor on Tuesday evening, February 16th.

Inspiration Consolidated Copper Co. is completing its new mill of 10,000 tons daily capacity. Some changes may increase this to twelve or even fifteen thousand tons. Operations are scheduled to begin in April. The estimated cost of copper production is 8½ cents per pound.

The establishment of tin smelting in the United States is one of the possible industrial advantages that can accrue to this country as a result of the European war. Both Bolivian and United States interests might profit by such an arrangement, for Bolivia apparently has supplies of the raw material, and the United States is a large importer and consumer of the metal. Bolivia has been shipping annually from 30,000 to 40,000 tons of tin concentrates to Europe for smelting, while this country imports several times the quantity of tin represented in Bolivia's exports. The metallurgical problem would not be difficult, and the industry could be established here if transportation arrangements can be concluded.

Feldspar as a Possible Source of American Potash*

BY ALLERTON S. CUSHMAN AND GEORGE W COGGESHALL

Two years ago the authors presented a paper before the eighth International Congress of Applied Chemistry, entitled "The Production of Available Potash from the Natural Silicates." This paper** not only presented a general discussion of the work that had been done by a great number of investigators in this field, but also described the results of practical mill runs made by the authors on the large scale of operation. This work had been carried to a successful conclusion as far as the purely chemical engineering side of the problem was concerned, but for reasons which seemed important at that time, no presentation or analysis of cost data was included in the first publication.

As a rule, no worker is in general so much hampered by complex commercial situations in his particular field as the chemical engineer, and this is particularly true with respect to potash problems which rest more or less insecurely upon a network of local, national, and international regulations, economics, and special arrangements. The prices of crude and finished potashes have not in the past rested on the firm basis of cost of production and transportation, modified by the just law of supply and demand, but have been subject to unstable arrangements between national governments and international syndicates. The governments of great nations make bad partners for industrial enterprises in these uncertain days, for they themselves seem to be unable to guarantee the validity of their own contractural agreements. Furthermore, the fixing of prices of a necessity of industry and agriculture by international or national syndicates, by which the interest of the ultimate consumer can not be a prime consideration, is utterly opposed to the present-day tendency in the development of human affairs.

It is one thing to work out a complicated problem in chemical engineering to a successful technical working status on an encouraging basis of costs, but it is quite another thing to assume the responsibility of inducing capital to embark upon an unknown sea of enterprise, especially if this sea is strewn with uncharted rocks and shoals, one, at least, of which may represent the cutting of prices by foreign producers to or below the cost of production for a sufficient period to kill off newborn competition, with the idea of averaging up profits at some future time when the infant industry shall have been effectually strangled. As chemical engineers, however, we may take some comfort for the future from the thought that such premeditated arrangements are becoming unfashionable, if not dangerous.

It is the purpose of this second paper, which may be considered an elaboration of our earlier publication, to present the results of some additional investigation, together with a frank discussion of the cost data involved in the possibility of using American feldspars as a practical source of American potashes. Many workers in this field believe it to be a self-evident fact that the potash alone would not pay the cost of extraction, or, in other words, unless the potash yield was merely a by-product recovery in the manufacture of some valuable main product, the attempt to extract it would be foredoomed to failure. After having made a close study of certain phases of this problem, continuing over a period of many years, we wish to state that in our opinion the economic feasibility of turning to the feldspars as a source of potash is, to say the least, open to debate.

*A paper read before the American Institute of Chemical Engineers, at the Philadelphia meeting on December 2, 1914.

**Abstracted at some length in this journal, November, 1912, p. 727.

Feldspar can be obtained in unlimited quantity favorably situated to our freight and trade routes in this country, which will run quarry-wise 10 per cent in potash (K_2O). The raw material supply, as far as potash ore is concerned, resolves itself, therefore, into a mere question of economical quarrying operations at the usual well-known costs. A comparatively small quarry of such feldspar, containing 1,000,000 cu. ft. of rock, or 100 ft. in cube, would contain 17,000,000 lb. of potash (K_2O) which, if it could be extracted, would be worth even at ante-bellum prices, $700,000. One ton of such an ore would contain 200 lb. of potash, worth, if it could all be extracted, about $7. If we assume, however, that only 75 per cent of it would yield to a chemical engineering process, we still have $5 per ton in value to work for. When we remember that in large-scale operations in the gold-mining industries, quartz that carries no more than $2 per ton in valuable constituents has been profitably worked, the problem need not necessarily frighten us away at the outset.

During the fiscal year ending June 30, 1914, there was imported into the United States $15,000,000 worth of potash salts, kainit, manure salts, muriate of potash, and sulphate of potash. In addition to this, considerable quantities of caustic and carbonate of potash, not included in the later available statistics, were also imported. Of the total, $8,000,000 worth was muriate of potash. The fertilizer industry uses, of course, the larger proportion of these potash importations, the percentage in the last few years being about 85 per cent of the total of muriate of potash imported, there being left about $1,000,000 worth of muriate of potash which was used in industrial work. About half of this total, or $500,000 worth, was used to make caustic potash and carbonate of potash. These are used principally in the soap industries, although a portion is used as a wrapper-tobacco fertilizer and in the manufacture of glass, paper, preparation of colors, in printing, in photography, and in more strictly chemical industries. Some nitrate of potash is manufactured from the chloride. About one-eighth of the muriate is manufactured into chlorate of potash at present, which is largely used in the growing safety-match industry. Potash bichromate uses about one-twentieth of the muriate and this is used in textile and color industries; also in photography.

Before proceeding with an analysis of cost data involved in the possible use of feldspar as a potash ore, it will be well to consider briefly the present sources of the world's supply. The German mines, located principally in the neighborhood of Stassfurt and Magdeburg in Prussian Saxony, have been for the past seventy years the principal source of the world production of the various potassium salts. Prof. O. N. Witt, in an article in the *Chemiker Zeitung* of Oct. 8, 1914, states that borings in Alsace have shown favorable deposits which may prove to be of considerable value. This is interesting news in view of the present doubt as to the future political status of Alsace-Lorraine. The reported discovery of soluble potassium salts in the province of Catalana, Spain, has recently commanded considerable attention and was prominently mentioned in the last annual report of one of our large agricultural chemical companies. According to our latest consular reports under date of Nov. 6, 1914, potash has not been extracted in Spain up to the present time in commercial quantities.* If the Spanish prospects should develop so that they would become a basis of a world trade, they would be welcomed for breaking an existing monopoly, but the source of supply would still be oversea, whereas North American independence in the commodity is highly desirable.

*Consul General Carl Hurst's report in Daily Consular and Trade Reports, Dept. of Commerce, 261, 615.

An American source of potassium salts in any considerable or practical quantity, in spite of much expensive government and private exploration, has not yet been discovered. In the Far West the giant kelps of the Pacific Coast, some of the brines and bitterns of the saline lakes and wells, and the alunite deposits of Utah and Arizona have been proposed and studied as possible sources of potassium compounds. The fact remains, however, that up to the present time three-quarters of all the potassium salts used in agriculture are consumed east of the Allegheny Mountains, by far the greatest quantity going into the three states of North and South Carolina and Georgia.

The reasons for this segregated demand for potash fertilizers are not at once apparent. The authors have made inquiries and have received the following explanations: Cotton, tobacco, intensive orcharding, and truck farming use the largest quantities of artificial fertilizer, while, in addition to this, the educational propaganda of a large Southern agricultural chemical company has demonstrated in its more immediate territory the economy of the proper additions of fertilizer to the land. The great effort which is now being made throughout the country to bring up the yield per acre of all our crops, will in all probability largely increase the use of all fertilizing materials not excepting potash.

It is unlikely that even the Panama Canal under the present tolls system would enable Western potashes to meet European competition on the Eastern seaboard. The fact that the great feldspar dykes of the Appalachian system are in general located in close proximity to the places where potassium salts are in greatest demand makes a special appeal to the chemical engineer. That the growing use for potassium compounds in intensive agriculture and industry will some day make use of the huge quantity locked up in the silicates, seems a safe prophecy. Whether that time has yet arrived is now open to debate.

In this paper, the authors will confine themselves to a discussion of their own methods and chemical engineering experience. There is no intention to ignore the fact that other workers have also proposed or to some extent developed methods for extracting potash from feldspar, either with or without the simultaneous production of valuable by-products. With any or all such methods the authors are not in conflict or debate, the present object being merely to open the subject to discussion along a well-known line. If any other source or method of economically producing American potash is discovered, the authors will follow its development with much interest.

Our previous paper described the working of the process by which the insoluble potash in the feldspar rock was simply converted into the soluble chloride salt, but no separation of this soluble salt from the residual rock was made. The product contained about 4½ per cent water-soluble potash (K_2O) in the form of 7.1 per cent of muriate of potash (KCl), also about 16 per cent of free lime, and the balance was the insoluble mineral material. It was solely a potash-lime fertilizer.

Several hundred tons were produced in regular mill working, and twenty-four hour-a-day runs were made, so that the feasibility of producing this material continuously and regularly was fully demonstrated.

This fertilizer was distributed free of all charges to some score or more of state experiment stations and large growers in many states for field trials as a straight potash-lime fertilizer to be compared with other potash fertilizers, such as wood ashes and various mixtures.

The field results were very favorable, as was to be expected from a material of this composition.

As will be shown later, the cost of production of such a potash fertilizer was low but the added expense of freight charges on a material containing so much inert matter was a serious drawback.

Muriate of potash is the chief potash salt imported into this country. It is sold on the basis of "80 per cent muriate" and usually contains from 70 to 80 per cent KCl, or from 44 to 50 per cent K_2O. This material, having its values in such a small bulk, will bear the cost of freight shipment easily. It is the cheapest potash salt for use as a raw material for chemical manufacturing, and is also well adapted for mixing into general commercial fertilizers. Any potash salt, however, running not less than 17 per cent K_2O (or 26 per cent KCl) is adapted for use in mixed fertilizers. A salt lower than 17 per cent K_2O could only be used where the final K_2O content in the complete fertilizer was to be less than 5 per cent.

Therefore, for the uses of the fertilizer industry, the economical production of any material containing 26 per cent, or higher, of KCl, would find large use, but for the replacement of all or a portion of the one million dollars' worth of concentrated muriate salts used yearly in the United States for chemical manufacturing, it is necessary to produce a salt containing at least about 70 per cent KCl.

Our experimental work was continued with the idea of separating and concentrating the soluble potash salts unlocked by this process, and giving a product so concentrated and pure that it may be used either in making fertilizers or be worked up into other potash compounds for more strictly chemical uses.

The salts are easily leached out from the mass as it comes from the furnaces, and by proper methods a solution of about 10 per cent KCl can be obtained, using the wash liquors for leaching new material. The evaporation of large amounts of water is a serious problem in chemical industry and in this particular case it could not be accomplished cheaply by any of the usual methods of evaporation.

The engineers working on this problem, however, have had considerable experience with methods of evaporation by the direct use of hot waste stack gases. A Porion evaporator, using such gases, is an extremely cheap method of evaporation with furnace gases, provided the material in solution is not harmed by the gases themselves. Even cheaper than this is the method of spraying the liquor through the waste hot gases. Experience with this operation has developed such successful results that it was adopted for this particular work. This use of the hot kiln gases, otherwise wasted, has an added advantage in the potash process from the fact that any volatilized KCl is caught at the stack washer.

The chief technical difficulty in the conversion to KCl was due to the high temperature produced by the powdered coal flame. When the charge, moving down the kiln, is brought up to about 1050 deg. C. the reaction is complete and there is then present in the charge free KCl. If the material is then further heated beyond 1150 deg. C., some of the KCl is volatilized and passes as vapor toward the stack. This final over-heating of the charge, and the volatilization of KCl, may be prevented by the use of a rotating combustion chamber attached to the lower end of the kiln, the charge passing outside of the extremely hot zone which is inside the combustion chamber. This arrangement prevents all over-heating and is so effective that coal itself is dried by this means, in a rotary dryer, with heat from burning powdered coal, the hot zone being confined to the combustion chamber rotating with the kiln. Small burners must be used in such cases, however, and in this potash work it is better to over-heat than under-

heat the charge to obtain the full yield of soluble product. In the mill work described in our previous paper, when no rotating combustion chamber was used, about 16 per cent of the KCl was volatilized during its passage through the hot zone of the kiln. This is now all caught in the stack-washer.

The complete process for the final production from feldspar of potassium chloride salts similar to the concentrated muriates imported from Europe will now be outlined.

A mixture of ground feldspar, containing about 10 per cent of K_2O, and burned limestone, is formed into rounded aggregates or "clumps" about ¼ inch in diameter, by the device already employed, using a solution of calcium chloride for this purpose. Calcium chloride is the by-product of the ammonia-soda alkali process and is the reactive agent in unlocking the potash from the silica. Mixtures of powdered rock and dry calcium chloride are almost impossible to make due to the attraction of the chloride for moisture. Moreover, simple mixing of two materials in the form of fine powders does not give an intimate enough contact of the reacting particles to produce good yields in furnacing operations in which neither of the particles is melted, so as to "wet" the other. In this particular case it was found that a proportion of burned lime mixed with the powdered feldspar will unite with $CaCl_2$ from a solution sprinkled on the powder, to form an oxychloride compound which cements the whole powder into aggregates, giving such a very intimate union of the particles that when heated the reaction yields are high. These aggregates or "clumps" pass directly into the rotary kiln heated either by oil or powdered coal flame. The clumps fall out of the kiln in the same form in which they entered it, but the potash has been converted from the insoluble form into the water-soluble muriate. These red-hot clumps fall into water in leaching vats, where the potassium chloride goes into solution. Several of these leaching vats are used so that the solution of the salt, the leaching, washing, etc., is continually performed. The strong solutions are pumped to the evaporators. The weaker wash liquors are used as leaching liquids for a new lot of processed clumps. The strong liquor containing roughly 10 per cent of KCl will be continuously sprayed down through the hot gases passing out of the kilns to the stacks. This operation is well known and has been studied particularly by our engineers.

The bulk of the water in these solutions is thus evaporated and only very concentrated solutions or sludges are allowed to pass out. These very strong hot liquors are finally dried out in a rotary dryer placed at the head of the lime-burning kiln, using its hot waste gases. The crusts formed are then ground for the market.

The concentrated solution before complete drying contains a small proportion of sodium chloride, corresponding in amount to the proportion of Na_2O in the original feldspar. On a spar running 10 per cent K_2O the Na_2O content has averaged from 1½ to 2 per cent. This would give from the liquors completely dried at once, without any fractional separation of the NaCl, a product having about the following composition: KCl, 70 to 80 per cent; NaCl, 14 to 16 per cent, and the balance a very small amount of lime salts and moisture.

To compare this initial product with imported German muriates, we give in Table I analyses, upon which such salts are usually bought in this country.

It is thus seen that without any attempt at fractional separation, muriate of potash may be made from our American feldspars, equal in character to the usual imported muriates, and that they are as well adapted to be used in commercial mixed fertilizers as those imported.

TABLE I

	70/75 Per Cent Muriate	80/85 Per Cent Muriate
KCl	72.5	83.5
K_2SO_4	1.7	....
$MgSO_4$	0.8	0.4
$MgCl_2$	0.6	0.3
NaCl	21.2	14.5
$CaSO_4$	0.2	....
Insol	0.5	0.2
Water	2.5	1.1
	100.0	100.0

If the hot concentrated liquors are not at once brought to dryness but are given a fractional crystallization treatment, which may be made a continuous operation, whereby most of the NaCl is removed, the KCl crystals then obtained will run pure enough to enable their direct use in the manufacture of chemicals of a high grade of purity. It may be noted that the purchasing analysis of German "90/95 per cent muriates" runs KCl 91.7 per cent and NaCl 7.7 per cent.

However interesting a workable process may be, it must, in order to be successful, produce the final product at a cost less than that of the same material obtained elsewhere. The costs of producing muriate of potash by this process will now be considered somewhat in detail, as we wish to present this subject for the careful consideration of engineers and manufacturing interests in this country.

The plant required is equipped in a general way similarly to a Portland cement mill. There must be rock hoists, trackage, crushers, rolls, rock dryers, grinding mills, a rotary line burner, the "clumpers" and rotary kilns, coal dryer and grinder, besides bins, elevators and conveyors, also leaching vats, tanks for strong liquors and for wash water, pumps, flue arrangements at stack for spraying the liquors, dryers and pulverizer, also air compressor and general power plant, stairs, ladders, handrails, and buildings to house the plant.

Plant costs and annual charges. In order to get the best idea of the various costs, we shall take a concrete example of a plant large enough to handle 300 tons of feldspar per day of 24 hours, this plant being a good-sized commercial undertaking. Such a plant will require three rotary kilns each 100 feet long and from 7 to 8 feet in diameter. We may conveniently divide the plant costs into two parts: (1) Those for equipment usually present in Portland cement mills, and (2) those for special equipment and rearrangements necessary to carry out these potash processes.

(1) The equipment usually found in a cement mill of this size, which would be used in the potash work, is given in Table II.

TABLE II

Quarry hoists, trackage, cars and tools	$4,000
Crushers, rolls, grinding mills	17,140
Rock dryers	4,600
Kilns (3), 7 ft. diam x 100 ft. (to 125 ft.) long	24,000
Air compressor and piping	2,000
Power plant	20,000
Buildings, stairways, handrails, etc	16,000
Miscellaneous equipment (14 per cent)	12,260
Total	$100,000

(2) The special equipment and rearrangements required are itemized in Table III (p. 102).

Now, if 5 per cent interest and 7 per cent depreciation are figured on the first item of $100,000, the yearly

TABLE III

Belt conveyors	$850
Screw conveyors	1,350
Elevators	4,300
Feeders	600
Chutes and gates	1,140
Bins for dry operations and $CaCl_2$	7,000
Lime kiln and burner	5,000
Oil or coal bins and incidentals	1,000
Clumpers (3)	5,000
Leaching, wash tanks and supports	18,400
Stack alterations and spraying apparatus	1,800
Liquor dryer and stack	2,800
Stack base	400
Disposal system (sludge)	1,000
Pumps and solution piping	3,500
Line shafting, pulleys and foundations	700
Miscellaneous foundations	250
Miscellaneous walkways, etc	600
Contingencies	7,810
	$63,500
Superintendence, etc.	6,500
Total	$70,000

fixed charge is $12,000. It may be possible to lease a cement mill with this equipment for this amount per year, and, if production was desired rather quickly, such a procedure would recommend itself. If the annual charge on this investment is then taken as $12,000, and there is added to it 5 per cent interest and 10 per cent depreciation on the cost of the special equipment, $10,500, we have as the annual charges to plant investment $22,500, or $64.30 per day.

Raw Material and Costs. We think there is a quite general misunderstanding as to the cost of the feldspar for this use. The only considerable use at present for feldspar is for the production of white china and porcelain ware, and for this purpose it must be free from iron-bearing minerals, such as biotite, garnet, hornblende, tourmaline, etc., in order that it will burn white. Therefore, all the feldspar that is put upon the market must be hand picked and iron free, and for such material the prices run from $3 to $5 a ton. For the purpose of producing potash salts from feldspar, it is not at all necessary that the raw feldspar be free from iron. In fact, this process should rightly be called a process for producing potash salts from "feldspathic rock" instead of from "feldspar." Feldspathic rock underlies a large portion of the Appalachian system. Feldspar, free from iron, is a special mineral, occurring in dykes of high purity.

For the purpose of this business, what are now called "feldspar properties" would not necessarily come into consideration at all. The procedure would be to buy by the acre certain lands well located for the purpose and get the feldspathic rock out by open quarrying operations, the costs of which are low and are quite well known. Limestone is quarried rough for about 20 cents per ton and cement rock is quarried in the Lehigh district for about the same cost. We have figured the cost at 50 cents per ton, and have allowed an equal amount for freight, making the cost of crude feldspar at the mill $1 per ton. This low freight charge is made as it would be good policy to have the mill near the feldspar property, and we regard this cost per ton as obtainable. However, we later on give the change in the final cost of the product with change in cost of the raw feldspar. Three hundred tons of feldspar per day at $1 would be $300 per day or $105,000 per year.

The potash is unlocked from its combination as double silicate by the reaction with calcium chloride under heat, the potash and any soda present uniting with the chlorine, forming alkali chlorides. One part of K_2O requires theoretically 1.18 parts of $CaCl_2$, and one part of Na_2O requires 1.79 parts of $CaCl_2$. A feldspar rock containing 10 per cent K_2O and 2 per cent Na_2O will require 15.4 parts of $CaCl_2$. A charge of 300 tons of such feldspar will therefore theoretically require 46.2 tons of actual $CaCl_2$ and in practice some excess of the reactive agent is used. The technical difficulties encountered in making and handling mixtures of feldspar and dry calcium chloride and the means by which these difficulties were overcome, were fully described in our earlier paper. By having a small proportion of free quicklime mixed in with the pulverized feldspar, and by an automatic device by which a strong solution of calcium chloride is continuously sprinkled on a moving layer of the powder, separate aggregates or "clumps" are formed, due to the combination of the free lime with the calcium chloride, with the formation of an oxychloride compound which cements the masses together into an extremely intimate union. The chlorine seems to be in a much more reactive condition in this temporarily formed oxychloride compound than the chlorine in straight calcium chloride, although the higher reaction yields obtained may be due merely to the far more intimate contact of the particles composing the clumps. These clumps are run directly into the rotary kilns.

This automatic method of preparing materials for furnacing operations costs only a few cents per ton and in this and in other furnacing processes it is greatly increasing the reaction yields. It is one of those simple aids to chemical manufacturing procedure which is tending to make continuous operations replace the methods of treating separate batches, and while often increasing the yields, it always decreases the costs.

We shall therefore figure the costs, using for every one hundred parts of feldspar twenty parts each of lime and calcium chloride, or for the plant we are considering, sixty tons of each per day. Provision has been made for a rotary limestone-burning kiln. Limestone can be quarried, brought to the mill and crushed to rather small size for under $1 per ton. At this figure the raw material cost per ton of lime will be $1.70. The cost for burning will be 63 cents per ton, the items of this cost being shown below in the figures for furnacing the feldspar mix. This gives $2.33 as the cost in the mill for a ton of unground lime and the daily charge will be $140 or $49,000 per year. It may be mentioned here that unusual care in burning the limestone is not required, although good burning is advisable.

Calcium chloride is the by-product of the ammonia-soda alkali process and is produced in great quantities in this country. A large portion of the amount produced finds no ready sale. It may be obtained in solid form containing about 75 per cent $CaCl_2$ and the balance water, or in solution in various strengths. The solutions used in our work are quite strong, between 35 and 40 per cent $CaCl_2$, so that the original solutions shipped in tank cars are suitable for the purpose. The questions of freight charges on the water content of solutions and solid cakes as affecting the final cost at the mill of the actual calcium chloride has been gone into quite fully, and we feel justified in stating that in our opinion the net cost per ton of calcium chloride at the mill should not exceed $7.33. The sixty tons required per day will then cost $440 and per year $154,000. However, we later on give the change in the final cost of our product with change in cost of the calcium chloride.

Manufacturing Operations and Costs. Feldspar crushes and grinds more easily than limestone or cement clinker; it breaks easier due to its cleavage planes. It has been found that a high speed mill which will grind 5 tons per hour of crushed limestone so that 65 per cent

will pass a 100-mesh screen, will grind 8 tons of crushed feldspar to the same degree of fineness. The operations of crushing, preliminary grinding and fine grinding of the feldspar and the lime so that over 95 per cent of the mixture will pass a 100-mesh screen will cost about 16 cents per ton for power, 14 cents per ton for labor, and 10 cents per ton miscellaneous expenses, making 40 cents per ton total. The labor charge is for three shifts of six men each. This gives the cost for crushing and grinding the feldspar as $120 per day or $42,000 per year. Using the same figure per ton, the crushing of the limestone and grinding of the burned lime is $24 per day or $8,400 per year.

The power required for the clumping operation is very small for a pump, elevator, feed roll and conveyor. Three shifts of four men each can handle it. The costs are per ton clumped, power 1 cent, labor 8½ cents, miscellaneous 3½ cents, total 13 cents, making a daily charge of $46.80 or $16,380 per year.

The furnacing charges for heating the feldspar clumps are considerably less than those for burning Portland cement, as less heat is required, the maximum temperatures in the kiln being about 1100 deg. C. or 2000 deg. Fahr. In our work with cement kilns it was found necessary to reduce the size of the coal burners, and cut the amount of coal fed in by at least one-third or overheating would result. The coal requirements in burning limestone in rotary kilns show about the same reduction from Portland cement requirements, although a ton of quicklime requires the heat from about 75 lbs. of good coal for the actual decomposition of the limestone from which it is made. We do not know the amount of heat evolved or absorbed in the union of K_2O with the silica and alumina in the formation of feldspar, nor do we know the amount of heat evolved or absorbed when CaO unites with the same substances. The following data, however, is available:

$(K_2 + Cl_2) - (K_2 + O)$ evolves 114,120 gram. calories.
$(Ca + Cl_2) - (Ca + O)$ evolves 38,990 gram. calories.

Using these figures above, in a double decomposition where on the one hand calcium is removed from $CaCl_2$ and unites as CaO with silicates and on the other hand potassium leaves its union as K_2O with silicates and unites with chlorine to form KCl, there is evolved an amount of heat equal to 1440 B.t.u. per pound of K_2O. This means that an amount of heat is evolved in the kiln at the reacting temperature, corresponding to 15.5 lbs. of coal for every ton of the charge heated in this process and by that much decreases the amount of fuel necessary to be burned. Our figures are 300 lbs. of coal per ton of burned clumps, but to this we add 20 per cent for the evaporation of the 17 or 18 per cent of water the original clumps contain. This gives a coal consumption of 360 lbs. per ton, or a cost of 45 cents per ton for fuel. Drying and grinding the coal costs 7 cents per ton of furnace product, power for the kilns 5 cents, a labor charge of three shifts of three burnermen each comes to 7½ cents per ton, and adding 5½ cents for miscellaneous expense gives 70 cents per ton furnacing charges on the 420 tons per day produced by this plant. The daily charge is $294 and for the year $102,900.

The leaching of the furnace product has been done in a small way, but it has not actually been carried out at present upon a large scale, as no plant has had the necessary equipment. A complete equipment has been designed for a mill of the capacity we are considering. Four leaching tanks per kiln, each with a capacity of 2800 cubic feet; one tank for strong liquor for each kiln, with a capacity of 5600 cubic feet; and one common wash water tank with a capacity of 19,600 cubic feet are provided, with all foundations, piping, pumps, walkways, etc. Also a re-arrangement of the usual stacks so that the liquors are sprayed down through the hot kiln gases and in the same direction in which these gases are traveling at the time, dampers, direct by-passes, and a system for disposing of the residual mineral sludges to the dump. The power cost per day figures to $10.80; the labor of three shifts of five men each to $39.00, and adding $10.00 for miscellaneous expenses, the charge to this operation per day would be $59.80 or $20,930 per year. A 10 per cent solution of KCl pumped to the stack evaporators, if concentrated to a 30 per cent solution, will require the evaporation of 10.54 tons of water per hour in the three stacks. If the coal runs 13,000 B.t.u., this means the total heat from 0.91 ton of coal per hour. There will be burned in the kilns 3.15 tons of coal per hour, and it will require only 29 per cent of the heat generated in the kilns to effect this evaporation. This strong hot solution, pumped direct to the final dryer between the lime kiln and its stack, will require the evaporation of 3.7 tons of water per hour, requiring the total heat from 0.317 tons of coal. There will be burned in the lime kiln 0.44 tons of coal an hour or an excess of 40 per cent. Should this not be sufficient to effect the complete drying of the crusts of muriate of potash, and if it was necessary to add 50 per cent to the amount of coal burned, the added cost would be $9.50 per day which would increase the total charges per day only 0.64 per cent.

The totals of the above costs are therefore

	Per Day	Per Year
Overhead expenses on plant	$64.30	$22,500
Raw Materials	880.00	308,000
Manufacturing operations	544.60	190,610
Total	$1488.90	$521,110

Product. In our operation of this process in a Portland cement plant, 83.2 per cent of the insoluble K_2O in the feldspar was converted into KCl. This was done in a short kiln only 55 feet long and better results are possible in longer and more efficient kilns. There is little doubt that 80 per cent can be obtained in the plant under discussion. From a rock containing 10 per cent K_2O there would be recovered, therefore, in the final product 24 tons of actual K_2O in the form of 38.03 tons of KCl. This product should be about 80 per cent strength, therefore the actual final product will be 47.54 tons per day or 16,639 tons per year, running 80 per cent KCl and a trifle over 50 per cent K_2O, a material identical with "80 per cent Muriate" imported from Europe.

The cost of this product figures to $31.32 per ton. Table IV gives the costs in cents per pound and in terms of fertilizer units.

TABLE IV

	Per Day	Per Year
Product—		
(80% KCl = 50.48% K_2O	47.54 tons	16639 tons
Actual KCl	38.03 "	13310 "
Actual K_2O	24.0 "	8410 "
Cost per ton of product		$31.32
Cost per pound of KCl—		
Overhead		0.0845 cents
Raw materials		1.1570 "
Manufacturing		0.7161 "
Total		1.9576 "
Cost per pound of K_2O—		
Overhead		0.1340 cents
Raw materials		1.8333 "
Manufacturing		1.1346 "
Total		3.1019 "
Cost per "Unit" of K_2O		62.04 cents

Each change of 50 cents per ton in the cost of the raw feldspar rock changes the final cost of the K_2O in the product 0.3125 cents. Each change in cost of $1.00 per ton in the cost of calcium chloride changes the final cost of the K_2O in the product 0.125 cents.

If 80 per cent muriate of potash has been heretofore used at a cost in this country of $37.50 per ton, there is thus shown a saving by the above process of over $6.00 per ton or 20 per cent profit on the manufacturing cost. All the materials for the operation are to be had in this country, and the costs as established by the first plant would not be increased in the future by any foreign complications. As to whether the German syndicate will continue after the close of the present war, we can only say that it seems probable, as under no conditions now foreseen will the Stassfurt potash deposits be separated from Prussia nor will Prussia be separated from her potash deposits.

A very large production of muriate of potash from American feldspar rock would probably invite price cutting after the war. A reasonably small production, such as outlined in this paper, might supply the requirements of certain industries and still not be a large enough proportion of the whole amount used in this country to warrant a price war. Wise governmental measures might enable even a very large domestic industry to be built up, which would make us independent of foreign materials for this valuable and essential ingredient of our fertilizers. If the crop yields per acre are to be increased in this country, some such independence may be necessary.

The permanent assurance that the fertilizers of this country may be supplied from domestic sources and that miscellaneous industries such as the soap, glass, match, color, photographic and strictly chemical industries using $1,000,000 worth of potash a year can be assured of a constant source of supply would go far to stabilize a great many of our manufacturers and would, by so much, be an item of true progress, as the raw materials are not at the present time used for any useful purpose whatever.

It may be of some interest to record in passing that the present war conditions abroad have caused the market price of muriate of potash to rise. Last week we were quoted this material at about $100 per ton. If a plant of the size we have been describing was put into operation by leasing a cement mill and expending $70,000 on additional equipment, which could be finished in three months' time, and if the muriate of potash was sold at one-half the present quoted prices, or $50 per ton, the profits figure out as $26,300 per month. After three months' operation the plant would have been paid for and at any time afterwards the plant could be scrapped and a good profit still be made on the enterprise.

We have made no attempt to put a value upon the large amount of by-product rock matter. In the plant we have considered, there would be produced, figured on the dry basis, about 370 tons of this residue per day. It would have a composition about as follows:

Silico (SiO_2)	65.8%	
Alumina (Al_2O_3)	17.4%	
Lime (CaO)	13.5%	
Magnesia (MgO)	1.0%	
Potash (K_2O)	1.9%	(?)
Soda (Na_2O)	0.4%	
	100.0%	

Owing to the volatilization of ferric chloride, the material is almost pure white and might find use in the glass, pottery, porcelain or brick industries. It is similar in chemical composition to some clays except that it has a higher content of lime and a considerable proportion of this lime is already combined with the silica. Some use in glazes might be found. Although high in alumina, certain glass products might be made, using it in mixtures, particularly plate glass and some bottle glasses. Its freedom from color is a point in its favor and also the assurance of practically constant composition and physical condition. If 50 cents a ton could be obtained for it after being dried, the income would be about $120 per day. This would reduce the net cost of the 80 per cent muriate product to $28.80 per ton, and the cost of the K_2O to 2.85 cents per pound.

Conclusion. In concluding this paper, the authors wish to record the fact that they are already familiar with many strong arguments which can be used against the advisability of attempting to manufacture potash in the United States.

It is frequently stated that the Stassfurt potashes could be sold in this country for about one-third of the prices which prevailed before the war and still yield profits to the foreign mines. Whether this statement is accurate or not, we have no means of ascertaining, but even if it is nearly true, it clearly proves that the words used in the introduction to this paper were not too emphatic, in which it is pointed out that special interest rather than the cost of production has controlled prices. If potash has any bearing whatever, through intensive agriculture, upon the production and price of food crops, however indirect this bearing may be assumed to be, the control of the product by any single interest is unquestionably hurtful to the best interests of the people of this country.

In the opinion of some more or less well-informed persons, potash is not nearly so important to growing crops as the other principal plant foods, combined nitrogen and phosphates. In other words, there is a tendency in certain quarters to believe that the propaganda in favor of the widespread necessity for potash in fertilizers has been overdone and that our agriculturalists could rest contented with potash reserves in the soil for many years to come, provided other conditions are properly looked after. However this may be, it is difficult to persuade either the practical grower or the scientific agriculturist that he does not increase his yields and early bearing, by a wise use of potash in one form or another. Up to the present time, the statistics of our average crop yields per acre are not a source of pride to those of us who study such comparative data.

It is the earnest belief of the writers that the American demand for an American source of potash at a fair price will continue to increase in the future. Whether the time has arrived when any progress along this line can be made, still remains in doubt. The foregoing paper has been offered to the Institute with no pretence at settling this important question but merely as a contribution to which we invite the attention and consideration of chemical engineers and others who may be interested.

The Institute of Industrial Research,
Washington, D. C.

The Alaska Gold Mines company has started its new mill, the first unit of 1500 tons daily capacity having been placed in operation in January. It is expected that full capacity of 6000 tons daily will be reached by June. A special meeting of stockholders of the company was held Jan. 21 for the purpose of authorizing an issue of $1,500,000 ten-year, 6 per cent convertible debentures.

The Nipissing Mining Co. shipped from Cobalt during the month of December, 1914, bullion to the value of $535,864. The high-grade mill treated 175 tons of ore and shipped 1,093,510 ounces refined silver.

The Development of Continuous Counter-Current Decantation in Cyanidation of Slime

BY W. J. PENTLAND

Continuous counter-current decantation as applied to the cyanidation of slime from gold and silver ores, offers a simple, economical, and efficient method of treatment. The object of the process is to separate from the slime and recover the solution containing precious metals. The principle of the method, as its name implies, is to effect this separation and recovery by decantation of the valuable solution from settling slime, washing the dissolved metal from the slime by means of a counter-current of water and barren solution, and performing these operations continuously. The process is applied in a series of Dorr continuous thickeners, through which thickened slime flows from head to tail of the system, while washing solutions flow in the opposite direction. The slime becomes gradually impoverished and the solution steadily enriched. A general outline of the system is shown in Fig. 1.

Several years ago the opinion was held by some, and publicly expressed in the technical press, that the application of continuous decantation to the treatment of slime would be a backward step; that displacement by filtration was the logical mode of recovering dissolved metal from ore-pulp; and that dilution by decantation with these devices showed that the anticipated displacement of 1 ton of solution with from 0.8 to 1 ton of wash was not obtained, and that in practice from 2 to $2\frac{1}{2}$ tons of wash had to be given, thus producing considerable dilution. Operating cost, when complete washing was accomplished, was too high, and the desire for more economic results caused operators to look about for an improvement on filtration. In the meantime Dorr developed his continuous thickener which lent itself so well to schemes for handling slime continuously that continuous decantation received the impetus necessary to bring it into successful use. It is stated[1] that since 1910, when the first continuous decantation plant using these thickeners was operated, "over twenty plants have been erected or are now being installed to operate by this method."

Some Early Objections to Continuous Decantation

It was probably natural that when the process first came into use, more or less skepticism existed as to its feasibility, and that objections were raised that were due, in some cases, to a misunderstanding of the method. It is true that the process is not of universal application; but while it has its limitations, it is susceptible of a number of variations that make it widely useful.

Some opposition developed through a confusion of continuous decantation with continuous agitation. These are two distinct functions in ore-treatment; and if the ores to be treated vary so widely

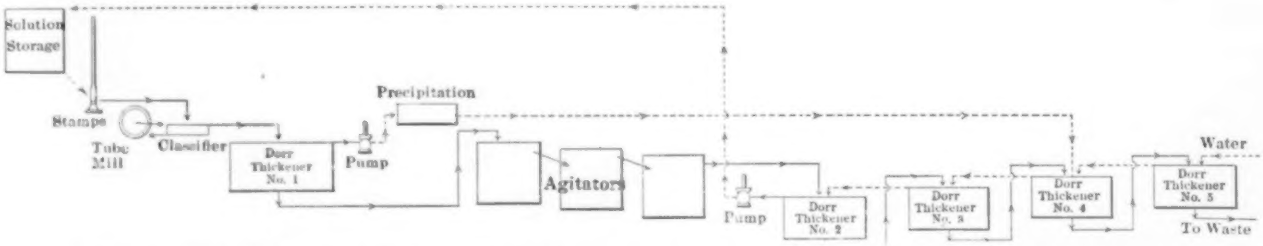


FIG. 1—DIAGRAMMATIC ELEVATION FLOW-SHEET OF CONTINUOUS COUNTER-CURRENT DECANTATION

was illogical. Since that time, however, continuous decantation has continued to show economy in practice to such an extent as to render the former contentions untenable.

Positive displacement methods, such as vacuum and pressure filtration, are theoretically ideal. They may even give better metallurgical results than can be obtained by dilution in continuous decantation; but if their economical results are inferior they must give place to more economical methods. As a matter of fact, continuous decantation has shown excellent results both in metallurgical extraction and economy of installation and operation, comparing very favorably with filtration processes.

The general adoption of a metallurgical system does not result from technical perfection alone; it is accomplished by superior economic results measured in dollars and cents. Filtration came into use, not merely because it was technically better than intermittent decantation, but because it was also economically better. It seems not unreasonable to assume that if, at the time operators were beginning to feel that some improvement on intermittent decantation must be developed, more attention had been given to continuous decantation, filters would not have come into such general use for recovering valuable solution, but would have been used mainly as dewaterers.

At the time filters were developed, however, satisfactory slime thickeners had not been produced, and attention was given to filters as offering the best solution of the slime-treatment problem. Subsequent experience in character that different periods of agitation are required, the agitating equipment should be designed accordingly. Such provision has always been made for intermittent decantation, and the same allowance must be made in the case of continuous decantation. The troubles and deficiencies of agitation must not be shouldered onto continuous decantation; if the former does not meet the requirements of the ore, the latter cannot rectify the trouble.

Within ten days of the time of writing, I visited a mill where the change from intermittent to continuous decantation is nearing completion. The agitation system is intermittent as before, and designed to meet the requirements of the ore; but a storage or equalizer tank has been placed between agitators and continuous decantation system. This mill has been treating over 300 tons daily and the change has been made without interrupting the regular tonnage. The management expects the remodeled mill to treat a larger tonnage than formerly.

Another point on which some were skeptical was the possibility of classification occurring during the flow of pulp through the successive thickeners, whereby heavier or larger particles of ore would become segregated. We have found, however, that where the ore is homogeneous, and the crushing and grinding departments yield a uniformly fine product, noticeable differences do not appear in screen analyses of the pulp at different points in the system.

An exception to this condition may occur when the ore

[1]The Dorr Hydrometallurgical Apparatus. By John V. N. Dorr. *Bulletin* A. I. M. E., Aug., 1914, p. 2063.

contains two widely different gangue rocks, such as quartz and clay. A pulp of such material cannot be thickened beyond a certain point, and any attempt to do so will result in discharging the quartz from the thickeners faster than the clay, leaving the latter to accumulate until it appears in the overflow. The correct density for such a pulp must be determined by experiment in order to avoid this segregation. Should slime appear in the overflow of the thickener, the quantity of moisture in the discharge must be increased until normal conditions return.

Another objection, which probably is more valid than those mentioned, is raised in connection with ores of such physical characteristics that they do not settle readily, requiring a large unit settling area, and discharging from the thickeners with too high a percentage of moisture. In a plant of large capacity treating such an ore as this, the required plant for continuous decantation might be too extensive, necessitating buildings of large area. Under such conditions, filtration might prove preferable, perhaps following decantation in one or two stages. The decanting process would even then serve to reduce the value of slime sent to the filters, and hence minimize the loss of dissolved metal in the filter cake.

No Serious Trouble from Occasional Interruptions

When a sudden and unexpected interruption of power service occurs in slime plants, a charge tends to settle and pack in the bottom of the tanks. With Dorr thickeners, however, no serious difficulty is encountered in bringing the charge into circulation again. At the moment of stopping, the rabble arms can be raised above their usual position so that they do not become packed in settled slime. On starting again, the arms are gradually lowered to their normal position, disintegrating the settled mass and moving it to the point of discharge.

With intermittent decantation in ordinary vats the conditions are not so favorable. Sand and slime pack in the bottom and cause much trouble in resuming operation. At one intermittent decantation plant of cone-bottom tanks, I attempted to secure washing of the pulp by discharging it into these tanks previously filled with the wash solution. The desired washing was accomplished, but the excessive dilution allowed the sandy part of the pulp to settle rapidly and plug the discharge. This difficulty was finally overcome by leaving a part of the previous charge in the tank, which sufficed to prevent rapid settlement of the sand.

In continuous decantation with Dorr thickeners the cost for repairs, power, and labor is much lower than for intermittent decantation. Dorr states[3] that "many machines (thickeners) are running to-day that have not cost a cent for several years." Power cost is low, ½ hp being sufficient allowance to make for each thickener when several are driven from the same lineshaft. In fact, the power required for the entire plant below the tube-mills is surprisingly small. In the new mill for the Rochester Mines Company, at Rochester, Nev., a 15-hp motor is provided to run three agitators, six thickeners and the necessary solution and slime pumps and shafting.[5] As for labor, "at the Anaconda four men per shift are more than enough to care for 160 tanks thickening 26,000,000 gal. per day, containing 2500 tons of solids."[6] When these conditions are compared with the labor of attendants in an intermittent decantation plant, lowering and raising decanting pipes, starting and stopping pumps and agitators, recording the progress of many charges through the plant, sampling and calculating tonnage on each charge, etc., some idea of the advantages of the continuous system will become apparent.

As for comparative capacities, the continuous system will handle from 40 per cent to 60 per cent more ore than can be put through an intermittent system, and do it cheaper and better. Under continuous decantation every tank is in active service all the time, while with intermittent conditions the tanks are working actively only about half time.

Simplicity of Arrangement and Operation

For simplicity of arrangement and ease of operation it would be difficult to excel a properly designed continuous decantation plant. All of the thickeners and agitators can be placed on one floor below the level of tube-mill discharge. Slight differences in the level of thickeners permit gravity flow of wash solutions. When diaphragm pumps are used for the transfer of pulp from one thickener to another they are placed at the top of the thickeners, and as a result the flow of all slime and solution can be observed from one floor at the average level of the top of the thickeners.

Concentration of plant in a small area, when favored with facility of operation, makes easier conditions for the attendants who can then be expected to perform their work properly. Too often plants are built to satisfy only the technical plans in view, taking it for granted that the attendants can always find a way to do their work regardless of plant arrangement. So they can; but it takes more of them to do the work and they do it less efficiently than in a well-designed plant. When, with concentration of plant and facility of operation, we also have simplicity of arrangement we are indeed favored. These are all obtained in properly designed continuous decantation as developed at this time. Once the rate of flow of pulp and solution is established, attention to the plant becomes simple routine.

A number of valuable plant accessories have been developed to aid the operator in maintaining uniform conditions. Diaphragm pumps furnish a means of moving pulp with positive measurement; the mechanism gives little trouble or wear. Overload alarms on thickeners, with electric bell attachment and graphic indicator, provide a check against carelessness and possible accident from too dense pulps. In short a continuous decantation plant is as near fool-proof as could be desired.

Gravity Flow of Wash Solutions

The general arrangement of a continuous decantation system with relation to the other departments of a mill, appears in Fig. 1, showing the relative levels of the different units. The five thickeners and three agitators can be arranged on one floor of the mill. Diaphragm pumps, not shown, are used to raise the thickened pulp from thickener No. 1 to the series of agitators, and from thickener No. 2 to No. 3, 3 to 4, and 4 to 5. Solution pumps elevate the overflow from thickener No. 1 to precipitation and from No. 2 to storage. Otherwise the flow of solution is by gravity. The precipitating apparatus is placed high enough to allow barren solution to flow by gravity to the desired point in the system, and the last four thickeners have sufficient difference in level, say, 2 ft., to permit gravity flow in countercurrent to the slime.

At first sight one might think that as it is easier to maintain solution pumps than slime pumps in good order, it would be more logical to arrange a gravity flow of pulp than of solution. There are a number of serious objections to such a plan. In the first place, the

[5] Ibid.
[6] This journal, November, 1914, p. 677.

[3] *Bulletin* A. I. M. E., August, 1914, p. 2060.

positive measured flow of pulp of uniform density is of great importance, and we cannot be assured of this by gravity flow through a fixed orifice. But if we transfer pulp by a mechanical device, such as a diaphragm pump, which at each stroke transfers a definite volume of pulp, we can easily maintain uniformity in the density of pulp transferred. If, temporarily, an undesirable change occurs in the density of the pulp, the pump will correct the condition; if the pulp is too thin, a larger relative volume of solution will be withdrawn at each stroke and *vice versa*. Such conditions cannot be obtained by means of a spigot discharge controlled by a valve. Furthermore, we have long since learned that the orifice of a valve plugs so easily as to condemn it for regulating the flow of pulp.

Another objection to gravity flow of slime through the system is found in the loss of mill-head that would result from the necessary arrangement of thickeners. With gravity flow of solution, the difference in level between thickeners is only about 2 ft., whereas an arrangement providing for gravity flow of pulp would require a difference in level between thickeners practically equal to the depth of the tank plus space for pipe and valve clearance. Thus the plant would resolve itself into a number of floors and the arrangement for driving the thickeners would be complicated. Furthermore, the power required probably would be greater, as approximately 1 hp would have to be provided for pumping solutions from tank to tank, as against 1/3 hp for elevating pulp by diaphragm pumps. In short, the arrangement of thickeners for gravity flow of solution gives us many advantages in construction, arrangement and power, and the elevation of pulp by diaphragm pumps corrects irregularities in density of the flow.

The air-lift can be used instead of the diaphragm pump for transferal, but it is usually not so satisfactory. It is especially recommended that the thickeners be equipped with overload alarms on the driving mechanism, and that the capacity of the lift be closely adjusted to the average flow of pulp.

The flow-sheet in Fig. 1 shows that the overflow from thickener No. 1 is precipitated. It is usually found unnecessary to precipitate this entire overflow in order to reduce the value of circulating solution. Any excess above the quantity precipitated can be returned to the mill-solution storage tank. In order to send a constant quantity of solution to precipitation, the overflow of No. 1 can pass to a receiving tank provided with a fixed orifice and overflow launder. As this tank will always be full, there will be a steady flow to the precipitation plant and thence to thickener No. 4. The excess solution overflowing the receiving tank can be combined with the overflow from thickener No. 2.

I recently visited a 100-ton mill using the continuous system, in which there were no sump or storage tanks. When operations were temporarily interrupted, the outlets of the overflow launder of the thickeners were plugged, thereby providing 8 in. or 9 in. additional depth in the thickeners for the storage of circulating solution until operations could be resumed.

Thorough Mixing of Pulp and Wash-Solution Necessary

A requirement of continuous counter-current decantation that must not be overlooked is the thorough mixing of wash-solution and pulp entering the thickeners. This can be accomplished by placing staggered baffles in the receiving launder and giving the latter sufficient fall from the periphery of the tank to the center to carry the mixed pulp through the tortuous path defined by the baffles.

From the launder the pulp can be received in a suspended central well in the form of a cylinder surrounding the vertical driving shaft of the thickener. The well can extend from 18 in. to 3 ft. below the level of solution in the tank and perhaps 1 ft. above. A suitable diameter for the cylinder would be also from 18 in. to 3 ft., depending on size of tank and dilution of pulp. Floating loosely within the cylinder, a wooden baffle can be placed to break the force of the incoming stream of slime solution. The baffle can be made in two pieces for convenience in case of removal, and it has an opening through which the vertical shaft passes. This device will reduce any tendency to form currents in the settling slime and will be an aid to quiet settlement, especially if the capacity of the thickener is being pressed to the maximum.

In case the thickeners are all on the same level, as for example in a remodeled plant, it may be necessary to make special provision for the mixing of pulp and wash-solution, as this cannot be done in launders.

To digress a moment, I see no particular advantage in the circular overflow launder that accompanies Dorr thickeners. This launder is expensive to construct and difficult to level, and it has but one side available to receive solution. Instead of this circular launder I suggest one of hexagonal form. For example, in a thickener of 24 ft. diameter, a hexagonal launder constructed of six 12-ft. sections could be supported in the tank at six points equidistant on the inner periphery. This launder would measure nearly 72 lin. ft. around its outer edge and nearly 66 lin. ft. on the inner, or a total of 138 lin. ft. available to receive overflow. A circular launder for the same thickener would measure about 75 lin. ft., and have but one side available.

Variations of Continuous Decantation

An important feature of the continuous decantation process as developed by Dorr is that, from data of tests on an ore, the probable results in practice are susceptible of close calculation in advance; and the counter-current flow of solution can be varied to give the most economic results as regards loss of dissolved metal and mechanical loss of cyanide in the tailing. Different ores present individual problems; but when the mechanical and chemical requirements of an ore are known, the calculation of results gives an accurate forecast of what may be expected in practice.

To obtain the most economical results, the counter-current flow of solution can be varied, but the flow of thickened pulp is always in a regular and unbroken line from head to tail of the system.

From what has been presented it would seem that we may anticipate a wider use of this method of cyaniding slime as its advantages become better known. In some cases it may be wise to meet special conditions by adding a filter to the system, to reduce dissolved metal loss or mechanical loss of cyanide, or to dewater tailings for stacking or conservation of water. No attempt should be made to impose on continuous decantation any duties that it cannot perform economically; but on the other hand, it should receive careful consideration wherever it seems applicable. Past progress in its adoption has been conservative, and each new installation has increased our knowledge of its possibilities.

Guadalajara, Jal., Mexico.

Aluminium alloys of different types have been patented by W. A. McAdams, of Bay Shore, N. Y. One is a soft alloy, suitable for making metal foil. It contains 100 parts aluminium, 30 cadmium and 5 tin. Another, designed to make cast objects that will not tarnish, contains 100 parts aluminium, 20 silver, 10 zinc and 5 copper. The third is a casting alloy containing 100 parts aluminium, 18 copper, 5 zinc and 3 antimony.

Limitations of the Electric Furnace in the Manufacture of Steel Castings

BY G. MUNTZ

In the September issue of *Metallurgical and Chemical Engineering* Mr. Ivar Rennerfelt takes exception to certain statements made by the writer in his article published in the June issue of the same magazine, under the heading of "Tropenas Converters vs. Electric Furnaces for the Manufacture of Steel Castings."

From the arguments advanced it is clear that Mr. Rennerfelt has misunderstood the purpose of the comparison made between the converter and electric processes in general. The writer's object in writing his first article was not to prove that metallurgically the converter was superior to the electric furnace, as doing so would be defending a paradox; we only tried to bring out the fact that the electric furnace represents the ideal means of producing ideal steel, but that the great problem is to determine whether or not its use is commercially possible. Cases such as this are not uncommon in any industry and the best example can be put in the shape of a question, namely, "Why is diamond not superseding tool steel?" The answer is one of commercial impossibility. Diamond represents an ideal, which, like others, cannot be used commercially.

Among various problems, none presents more difficulty of solution than that faced by the foundryman, who, at the crossroads of progress, must choose between the newer and yet uncertain melting method, and the old, reliable and approved methods such as the crucible, the Tropenas converter and the open-hearth furnace.

It is clear, however, that any method used in the foundry must be able to compete with other processes, and it might, therefore, prove interesting to discuss the various points brought up by Mr. Rennerfelt.

Economy

Authorities in the United States agree that although cheap energy is one of the main factors in the economical production of electric steel, it is not of such great importance. W. L. Morrison, before the convention of the American Foundrymen's Association last September, stated:

"Steel can be melted and refined in the electric furnace for from $27 to $35 per ton in the ladle, depending on the power cost, cost of materials and the care of the melter. The electric furnace to-day is somewhat overrated by claims that it is especially adapted to all foundry use; that its operation is very simple and easily mastered, and that the hottest kind of metal is obtained, so that low-carbon steels can be poured in the thinnest sections. All these statements are more or less true, but should be investigated by the foundryman, so as to avoid disappointment after installation.

"There are some installations of electric furnaces which have been made during the past two years, which did not come up to the expectations of the foundryman, and were either abandoned or operated in a half-hearted way. An electric furnace installed with the idea that one heat a day will pay its way is disastrous to the foundry. The electric furnace, while adapted to foundry work under certain conditions, should not be considered as an ordinary piece of apparatus. It is very delicate or at least certain parts are, as one finds out in practice. A careless melter can add $5 to $15 to the cost of a heat from electrode breakage by neglecting to raise his electrodes during the removal of slag, or when charging the furnace.

"In the charging of the furnace a certain amount of care must be exercised to insure prompt electrical contact and smooth working of the electrodes. I think the electric furnace involves more good common sense and observation than any of the well-known methods of producing steel. It is very easy to lose an hour or even three hours by poor electrical contact at the offset, due to either poor charging or poor selection of scrap. Those who have had practical experience with the furnace know how aggravating a poor electrical contact is; on the other hand, a short circuit the moment the arc is made and subsequent surges of current are readily overcome by placing a little slag around the electrodes.

"The operation of the furnace and the reactions taking place appear so simple that the ordinary spectator is apt to be misled."

E. B. Clark, who probably has had more experience than any other in this country in the use of electric furnaces for manufacturing steel castings, stated in a lecture before the American Electrochemical Society last April that:

"The cost of production is the final answer from a commercial standpoint, and this depends not only upon the market for the intended output, but upon the available supply of steel-making materials, and upon the availability of a satisfactory and sufficiently cheap source of electrical power. In passing it might be observed that this question of electric power supply is generally not so serious as might at first appear. In the first place, there are many locations where a sufficient amount of fairly cheap electric power may be purchased, and in the second place, the item of power is not often of supreme importance.

"There are other elements entering in the production of electrically refined steel which have a far greater influence on the cost of production than is generally credited. The most important of these is experience. It should be understood clearly that the electric furnace is a more delicate apparatus than any of the usual furnaces employed. It is more difficult to handle and its operation offers more likelihood of mishaps. Electric furnace operation has not yet been reduced to standard practice. Melters familiar with its operation are scarce and difficult to find."

Speaking about low power consumption, Mr. Clark has this to say:

"As a matter of fact, claims for low power consumption by any furnace should be received skeptically. It is a fact that the power consumption of any electric furnace depends somewhat upon the efficiency of the furnace, but it also depends to a far greater extent upon the thoroughness of the heat insulation, for, after all, the only heat which is lost is that which escapes by radiation or conduction. That which goes out in the slag, or in the steel, depends not upon the efficiency of the furnace, but upon its mode of operation. Where a high degree of refining is necessary, slags must be taken off at the cost of power consumption. Where the furnace must be operated with considerable time between the heats, heat is escaping rapidly during that idle time.

"Where heats must be held in the furnace, or melted slowly, to meet a definite schedule, a high power consumption must be expected. For these reasons it appears that the claims for low power consumption of certain furnaces are practically valueless from an operating standpoint. The conditions of operation, rather than the type of furnace, are what control the power consumption, though, of course, the construction of the furnace, as regards heat insulation, does have some influence."

Ease of Operation

As far as operation of electric furnaces is concerned, it is the general belief that considerable care and knowledge are required, and to cover this point to some extent we can continue to cite Mr. Clark's paper:

"To attempt an answer as to what type of furnace is best is as unsatisfactory as to make general comparison between electric furnaces and other furnaces. If we could accept at face value the statements of a number of men interested in the development of certain electric furnaces, we could easily believe that as soon as a foundryman has installed an electric furnace (provided he installed the right one) his troubles would be at an end. As a matter of fact, he is apt to find that they are just beginning. In the first place, unless the design of the furnace has been thoroughly tried out in practice, it will certainly have to be modified considerably from the designer's ideas. In the second place, the user will certainly find the furnace to be a more delicate piece of apparatus than he had anticipated. He will find that while he can make steel of a very high quality, he can also make, without difficulty, much steel of a very low quality. If there are in the society some men who have been using electric furnaces for the production of castings or special steels, they will have no difficulty in recognizing these remarks from one who has had such experience.

"It so happens that the speaker's experience has embraced not only a study in this country and Europe of the design and operation of a number of different types of furnaces, but has embraced the actual operation of two typical types of furnaces for the production of steel castings. The investigation as to which general type of furnace is best led in my case, as in that of most others, to much confusion of ideas. It is so evident that each type has certain advantages and disadvantages, and so impossible accurately to gauge the proper importance of the various advantages and disadvantages, that one cannot reach a conclusion as to which type of furnace is best wih confidence in his conclusion. Perhaps the only way to learn is to try them all. As a matter of fact, the speaker has already tried two, and feels that he has not yet decided the question."

Refining Possibilities

It is granted that as a refining medium the electric furnace cannot be excelled, but whether such extensive refining as indicated by Mr. Rennerfelt is commercial is very doubtful, for such reasons as were already expressed above (number of slags, meeting definite pouring schedules, etc.).

At the April meeting of the Electrochemical Society Mr. C. A. Hansen pointed out that:

"Current opinion has it that one of the advantages of the electric furnace is that it can work up any sort of charge. While this may be true quite often, it is not well to base estimates of the cost of molten electric furnace steel upon the usual published furnacing costs, and upon the local prices for stove scrap and similar materials. Probably every operator of an electric furnace has at one time or another run off heats from charges composed of stove scrap or its equivalent, and little need be said for or against such a procedure."

On the other hand, we all know that in the electrical industry, for considerations of permeability, steel must be of as low carbon content as can possibly be obtained. In the Tropenas Converter such low carbon can be attained at *no additional cost*, and almost pure iron can be cast inasmuch as at the end of the usual converter operation the steel contains only 0.09 per cent carbon, 0.02 per cent silicon and traces of manganese. To cast such metal high temperatures are required and the converter process presents the only means of obtaining such results commercially. Mr. C. A. Hansen says on the subject:

"With the electric furnace maintenance costs increase rapidly as the carbon contents of the product is brought down, and quite contrary to current opinion, it is not economical to turn out 0.10 carbon steel castings, although it is perfectly possible to do so."

Other authorities agree as to the difficulties encountered in the electric furnace when producing low carbon steels.

Loss from Oxidation

It is true that converter loss runs usually about 7 per cent higher than that of the electric furnace, but the conclusions drawn by Mr. Rennerfelt are quite erroneous. The fact that there is a higher loss in the converter does not affect the chemical analysis of the metal. At the end of the blowing operation silicon, manganese and carbon are practically burned out so that there can be no undesirable uncertainty of analyses, inasmuch as the very elements characterizing the steel are almost absent.

This is even one of the great points of superiority of the Tropenas converter over the electric furnace. When blowing is stopped, the analysis of the bath in the converter is almost constant so that *any* composition of steel can be obtained by the additions of the proper elements.

The converter practice which has been referred to by Mr. Rennerfelt must have been very poor, inasmuch as in this country we consider 18 per cent the maximum (instead of 28 and 33 per cent) which includes both cupola and converter losses. As far as temperature of metal is concerned, we believe that if higher ranges were attained in the electric furnace than are obtained in this country under ordinary practice in Tropenas converters, the life and stability of electric furnaces would be considerably endangered.

The best proof to the effect that converter metal does not cause scrap on account of low temperature is that all converter foundries in this country cannot make enough scrap and have to buy from 15 to 20 per cent of their actual cupola charges. As a matter of fact, one of the hardest things to find in an American converter foundry is home-made scrap.

In American practice we operate converters with lower silicon and higher manganese contents in the charge without injury to our linings. This is probably due to the elimination of brick and the substitution of ganister for linings after considerable study and experimenting.

Supply of Raw Material

Most of the electric furnaces operating in this country are run on an all-scrap basis in order to eliminate delicate and costly refining. All-scrap melting is, in our opinion, the only commercial course open to the electric furnace for the reason that the very smallness of most steel foundries does not allow the hiring of expensive melters. If this line of least resistance is followed, the electric furnace will encounter conditions similar to those of the old crucible furnace days. The law of supply and demand enters here into consideration, and it is useless to discuss the point, because as long as a market is created for steel scrap, the prices are bound to rise, and as the general opinion prevails that for the purpose of producing steel castings the electric furnace will be used as a scrap melter pure and simple, such market was created by the introduction of the electric process.

Reliability

In the light of the fifty analyses of consecutive blows published in our previous article and considering also the fact that this record is only a part of a series of over 22,000 similar operations, it is hard to conceive how the Converter process could be called a "hit or miss" method. This same point was raised when the Tropenas converter was brought out, and we always

refer with pleasure to the tests which the British Admiralty conducted in order to determine whether the open hearth process was more uniform and more reliable than the Tropenas converter.

The result of these tests cannot be published, but the fact that several Tropenas converters were installed after the tests were completed speaks louder than words.

To the practical foundryman it is perfectly clear that wherever the personal equation does not enter into consideration, greater regularity and consequently greater reliability can be expected. As stated in our previous article, converter operation hinges around good cupola practice. There is no simpler furnace to operate than a cupola, the practice has been reduced to definite standards, so that the operation of the Tropenas converter itself is purely mechanical. The best proof of this statement is found in the very lack of understanding on the part of the average converter operator, of the actual reactions taking place during the blowing.

Suitability of Process to Product

Mr. Rennerfelt cites an article published in *The Iron Age* of March 27, 1913, by Mr. E. F. Lake, in which Tropenas converter steel castings are not treated in a very complimentary way. We were tempted, at the time the above-mentioned article appeared, to take up the cudgel for the converter castings, but the statements made were so evidently the product of great enthusiasm for a new method that we disregarded their being at variance with actual facts.

To anyone who has followed the development of the steel castings industry in this country it is known that the Tropenas converter has steadily displaced the crucible process, and we venture to say that the days are not far off when the number of crucible steel foundries manufacturing steel castings will be counted on the fingers of one hand.

The lack of control over carbon contents gave the crucible process its death blow, and the only surprise which can be evinced is that the other inconveniences inherent to this process had not forced its users to a change long ago.

Former crucible furnace men, who are today strong Tropenas converter enthusiasts, tell us that their product is today so superior to that they used to turn out that they are able to satisfy clients which the crucible had lost to them.

It will be of interest to note that in the automobile industry, where the utmost care has been exercised in the drawing up of rigid specifications, over 95 per cent of the steel castings used are the product of the Tropenas converter. It will also be of further interest to note that at least two large motor truck manufacturers who had found it to their advantage to purchase steel castings from one of the best electric furnace steel producers in Europe are now using castings made in the Tropenas converter exclusively.

We do not want the reader to infer from the above that steel castings produced in the electric furnace are not of the highest grade, because under good management the electric furnace will produce a superior casting, but under ordinary conditions the electric steel casting will suffer the disease of all things that are superior, namely, it will be too expensive for the quality achieved.

This leads us to remember the remark of one of our Boston friends who, when called upon to purchase an electric furnace instead of a Tropenas converter said, "Why buy silk stockings when cotton ones will do?"

Flexibility of Process

We are afraid that Mr. Rennerfelt's suggestion to use mixers in connection wih the electric furnace in order to increase the latter's range, is not very practical. The primary superheating of the steel or the suggested use of thermit would only add to the cost of a product which is already in great danger of being too expensive, and our suggestion would be to use the electric furnace within the range of its own capacity and make the best of a process which has no flexibility.

The pouring of castings weighing 3 or 4 times the rated capacity of any Tropenas converter is the simple result of speedy operation which is not and will never be met by any electric furnace.

It might be said in passing that contrary to the usual belief, Tropenas converters are not lined with bricks but with ganister, which accounts for the ease with which 3 operations can be made in an hour, 20 and even 25 in an ordinary working day, and from 36 to 40 without need of repairs.

Segregation of Steel Castings

If the leading authorities were to be consulted today regarding the order in which the various metalloids will segregate in steel, a goodly number of volumes would be filled with dissenting opinions. The writer's contention was based on the opinion that the electric furnace can be used commercially only as a steel-scrap melting device, and in such a case the final product will always be higher in carbon than the scrap used, because the analysis of the average steel scrap shows carbon contents which are too low for steel castings purposes.

The resulting "home scrap" made of gates and risers will produce a "building up" of carbon similar to that which is claimed to occur for phosphorus, sulphur and copper in the converter process.

If, according to certain authorities, carbon being present in larger quantities in steel than any other metalloid, segregates first then segregation will be greater in the electric process; if sulphur and phosphorus segregate first, the segregation will be greater in converter steel.

The above, however, is important only in the manufacture of ingots. In the production of steel castings such interest is not surprising when originating from the Tropenas converter, the bodies of metals are so small that segregation need not be considered.

Market for Various Steel Castings

We must thank Mr. Rennerfelt for the tribute paid by him to the various manufacturers interested in the production of better steel castings. The fact that inquiries are being made about electric furnaces proves without a doubt that interest has been aroused, but such interest is not surprising when originating from a country where it is almost a cult to produce "the best in the world."

One fact, however, must not be lost sight of, namely, that it is one thing to manufacture a product and still another to sell it.

American manufacturers are open to conviction. They are using old and tried methods for producing steel castings and we are sure that any medium of increasing quality will be received with favor. Its general use, however, will remain problematical as long as increased cost of production is not commensurate with betterment of quality.

Tropenas Converter Co.,
New York City.

The Nevada State Mining Laboratory, now organized as a department of the Mackay School of Mines, has for its object the free analysis of ores, rocks and minerals taken from within the boundaries of Nevada by citizens of the state. In 1914 assays were made for 804 persons who sent in 1631 samples from 248 localities. A total of 6533 determinations were made on these samples.

Presentation of the Perkin Medal to Edward Weston

The ninth impression of the Perkin Medal was presented to Dr. Edward Weston, president of the Weston Electrical Instrument Company of Newark, N. J., on the evening of January 22, 1915, in a joint meeting of the New York sections of the Society of Chemical Industry, the American Chemical Society, and the American Electrochemical Society. The medal had been awarded to Dr. Weston unanimously at the meeting last month of the Perkin Medal Committee, consisting of representatives of the above three and other allied chemical societies.

The meeting of January 22 was very well attended, many ladies being present, and lasted till almost midnight. It was called to order by the chairman of the New York Section of the Society of Chemical Industry, Dr. G. W. THOMPSON. The Perkin medal was presented to Dr. Weston by Dr. Charles F. Chandler, Senior Past President of the Society of Chemical Industry in America.

DR. CHANDLER'S PRESENTATION SPEECH

Dr. CHARLES F. CHANDLER, in his presentation address, spoke of the early life of Weston. Edward Weston was born on May 9, 1850, at Bryan, near Oswestry, Shropshire, England. While he was still young his father moved to Wolverhampton in Staffordshire, where he was educated under private tutors, receiving his first instruction in physics and chemistry.

By this time even he had already manifested a great taste for science and also for experimenting and occupying himself in the use of mechanical tools. His parents desired him to select some well established profession for his life work, and they first placed him with a dentist, but this did not suit his tastes. Then they tried him with two physicians, Dr. K. H. and J. E. Colman. He decided that he could stand surgery, but he did not like medicine. But these physicians exercised a most beneficial influence upon him because they were broad-minded scientific men, both of them in the habit of lecturing on scientific subjects and illustrating them by experiments. So Weston's interest in chemical, metallurgical and electrical subjects, which he had developed while he was still a boy, was greatly increased by his association with these men.

While still only sixteen years of age he delivered an illustrated lecture on electricity, performing the experiments with apparatus which he had himself constructed. The fact soon become apparent to him that he had no taste for the practice of medicine, so he determined to leave home and strike out for himself. Armed with some letters of introduction, he prepared to go to London, but on thinking the matter over he finally concluded to go to America and make a career there, which he certainly has done. He arrived in New York in May, 1870, with his modest library and outfit of chemical and physical apparatus, and a very limited amount of cash and a very simple wardrobe.

He began at once to look for employment, tramping daily through New York, Long Island and everywhere where he thought chemical operations were carried on. Finally he ran across the small concern of William H. Mardock & Co., manufacturers of photographic chemicals and dealers in photographic supplies and apparatus. Here he made his beginning, manufacturing pyroxyline and a general line of photographic chemicals, staying about a year. During this period and later, for about three years, he assisted Professor Charles S. Stone, Professor of Chemistry, at the Cooper Union.

He watched the daily papers and one day saw an advertisement for a man having some chemical and electrical knowledge, especially electroplating. He answered this advertisement and the next morning a man came to the store and inquired for Weston. This man was a representative of William H. Belden, president of the American Nickel Plating Company. After a short interview Mr. Belden proposed to engage him at once, but he felt that he could not leave his employers so suddenly, and arranged to continue his position with Mardock & Co. for a fortnight and to work nights in Belden's establishment. He found that the nickel-plating works were in very poor shape, especially the galvanic batteries employed as a source of electricity. He went to work immediately, put the batteries and other things in order and at the end of two weeks everything was working satisfactorily.

When Dr. Weston took his position with the American Nickel Plating Company he made most careful investigation into all the details of the art, and made many improvements in these details, by which he improved the quality of the coating, secured great economy in nickel, and greatly reduced the time required for plating, and particularly succeeded in the preparation of the surface to which the nickel was to be applied and in the polishing of the nickel coating. He also discovered a dip which could be conveniently used for removing nickel from damaged goods in order to coat them again. With these improvements the business of the company increased very rapidly and they nickel-plated the greatest variety of articles from a bunch of keys to a fire engine.

Owing to dissensions among the stockholders of the company, the business was finally given up. Weston then went to the Silver Nickel Plating Company about the middle of 1872. He found the process they were carrying on was entirely unsatisfactory and turned the place into a nickel-plating business. He soon left the company, however, and was appointed consulting expert by the Commercial Printing Telegraph Company, operating the patents of Foot and Randall. The company was soon bought out by the Gold and Stock Telegraph Company.

Dr. Weston then formed a partnership with a Mr. Harris under the firm name of Harris & Weston for general plating business; copper, brass, nickel, silver and gold. Here he built, in the latter part of 1872, a dynamo as a substitute for batteries in electroplating. This greatly increased his business, so he enlarged the plant and finally moved to Center Street. Here he built another dynamo, larger and somewhat different. Then he built a third dynamo for a manufacturing firm in Newark. At this time he withdrew from the plating business and made an arrangement with the Newark firm to build a dynamo for electroplating and made about twenty of them. They were so expensive, however, that they could only be used by large concerns. He started to design a simpler and cheaper machine, but the firm decided to give up the business. A new firm, Stevens, Robbins & Hayville, bought them out and Weston went into partnership in order to develop a new nickel anode which he had invented and for which he obtained his first patent in 1875.

Born in 1850, Weston was twenty years of age when he came to America in 1870, and he took out his first patent in 1875 at the age of twenty-five. The record of his varied

experience, his efforts and successes for the first five years of his working life is certainly very remarkable, and gave promise of all that he has accomplished since. He has taken out over 350 patents for his various inventions, and has made radical improvements in several arts. Besides that, a great deal of his work has involved the most patient and careful scientific investigations, often of microscopic accuracy, and has contributed largely to the advance of scientific knowledge and theory.

It would give me a great deal of pleasure to explain to you in detail the great variety of subjects which Dr. Weston has investigated and developed during the forty years since he took out his first patent, but as I am to be followed by Dr. Baekeland, Dr. Hering and by Dr. Weston himself, I must deny myself the pleasure.

In 1903 McGill University conferred upon Mr. Weston the degree of LL.D., in 1904 the Stevens Institute of Technology bestowed the degree of D. Sc., and in June, 1910, Princeton University conferred the same degree.

Edward Weston, Doctor of Laws and Doctor of Science, my dear friend: It gives me the greatest pleasure as the representative of the affiliated chemical and electro-chemical societies to place in your hands this beautiful token of appreciation and affection of your fellow chemists.

Dr. Weston, after receiving the Perkin medal, expressed his thanks in a felicitous little speech, in which he gave reminiscences of his first meeting with Dr. Chandler many years ago.

Dr. Baekeland's Speech

Dr. Leo H. Baekeland in his address on "Edward Weston's Inventions" said that Edward Weston's pioneer work was not easy to describe in a few words, as his restless inventive activity has been spread over so many subjects, has intertwined so many interlocking problems—electrodeposition of metals, electrolytic copper refining, construction of electric generators and motors, illumination by arc and incandescent lamps, and the manufacture of electrical measuring instruments. An impressive list of subjects, but in every one of those branches of industry, Weston was a leader.

But why was Weston able to overcome difficulties which seemed almost unsurmountable to his predecessors and coworkers in the art?

The answer is simple: He introduced in most of his physical problems a chemical point of view—a chemical point of view of his own; a point of view which was not satisfied with general statements, but which went to the bottom of things. He did not get his chemistry wholesale as it is dispensed in some of our hot-bed-method educational institutions. He had to get at his facts piece-meal, one by one, adjust them, ponder over them, collect his facts with much effort and discrimination; he did not acquire his knowledge merely to pass examinations, but to use it for accumulating further knowledge.

It seems rather fortunate for him that one of the first employments he got in New York was with a chemical concern which made photographic chemicals. This was the time of the wet-plate, when photographers made their own collodion, their own silver bath, their own paper. Whoever went through those delicate operations, knew the difficulties, the uncertainties which were caused by small variations in the composition of chemicals or in the way of using them. Photochemistry is excellent experience for any young chemist who is disposed to generalize too much all chemical reactions by mere chemical equations. Whoever has to deal with those delicate chemical phenomena, which occur in the photographic image, knows that many unforeseen facts can not easily be accounted for by our self-satisfying but often superficial generalizations of the text-books.

Weston's tendency to observe small details in chemical or physical phenomena led him to improve the art of nickel-plating and electrolytic deposition of metals to a point where it entered a new era. When he undertook the study of the difficulties in this art, he took nothing for granted, but by close observation, he succeeded in devising methods not only of increasing the physical texture of the deposit, but for improving enormously the speed and regularity with which the operations could be carried out; all these improvements are now embodied in the art of electrotyping, nickel-, gold-, and silver-plating.

At this time, attempts had already been made for the commercial refining of copper by means of the electric current. But this subject was then in its first clumsy period, far removed from the importance it has attained now among modern American industries. Here again, Weston brought order and method, where chaos reigned. His careful laboratory observations, harnessed by his keen reasoning intellect, established the true principles on which economic, industrial, electrolytic-copper-refining could be carried out. Dr. James Douglas (Commencement Address, Colorado School of Mines, *Metallurgical and Chemical Engineering*, Vol. XI, No. 7, July, 1913, page 377) referred to this fact in a recent address:

"I suppose I may claim the merit of making in this country the first electrolytic copper by the ton, but the merit is really due him (Weston) who in this and innumerable other instances, has concealed his interested work for his favorite science and pursuits under a thick veil of modesty and generosity."

The whole problem of electrolytic refining, when Weston took it up, was hampered by many wrong conceptions. One of them was that a given horsepower could only deposit a maximum weight of copper, regardless of cathode- or anode-surface. This fallacious opinion was considered almost an axiom until Weston showed clearly the way of increasing the amount of copper deposited per electrical horsepower, by increasing the number and size of vats and their electrodes, connecting his vats in a combination of series and multiple. The only limit to this arrangement being the added interest of capital and depreciation on the increased cost of more vats and anodes, in relation to the cost of horsepower for driving the dynamos.

The electrodeposition of metals forced Weston into the study of the construction of dynamos. Until then, the electric current used for nickel-, silver- and gold-plating, as well as for electrotyping, was obtained from chemical batteries. Weston says that it was almost a hopeless task to wean electroplaters from these cells to which they had become tied by long experience and on the more or less skilful use of which they based many of the secrets of their trade.

If the dynamo as a cheap and reliable source of electric current was advantageous for nickel-plating, it became an absolutely indispensable factor for electrolytic copper refining. At that time, the dynamo was still at its very beginning, some sort of an electrical curiosity. It had been invented many years before by a Norwegian, Soren Hyjorth, who filed his first British patent as far back as 1855. Similar machines had been built both in Europe and America, but little or no improvement was made until Weston, in his own thorough way, undertook the careful study of the various factors relating to dynamo efficiency.

Dr. Baekeland then sketched Weston's work in dynamo design, for which he worked out the first patent in 1876, and mentioned that the first practical application of electric power transmission for factory purposes in this country was in the Weston factory in Newark.

Weston's work in illumination was sketched next. Weston started the manufacture of arc-lamp carbons in this company which he continued until 1884. To improve the color he invented what is now called the flaming arc.

In relation to this invention, it is interesting to quote the following extract of the specifications from his United States Patent 210,380, filed November 4, 1878: "This rod or stick may be made of various materials—as, for example, of so-called lime glass, or of compounds of infusible earths and metallic salts, silicates, double silicates, mixtures of silicates with other salts of metals, fluorides, double fluorides, mixtures of the double fluorides, fusible oxides, or combinations of the fusible oxides with the silicates—the requirements, so far as the material is concerned, being that it shall be capable of volatilization when placed on the outer side of the electrode to which it is attached, and that its vapor shall be of greater conductivity than the vapor or particles or carbon disengaged from the carbon electrodes. The foreign material added to the carbon may be incorporated into the electrode by being mixed with the carbon of which the electrode is composed, or it may be introduced into a tubular carbon; but I have found it best to place it in a groove formed longitudinally in the side of the electrode, as shown."

In his endeavors to make the electric incandescent lamp an economic possibility, we see him introduce over and over again, chemical methods and chemical considerations. He first tried to utilize platinum and iridium, and their alloys, which he fused in a specially constructed electric furnace, devised by him, antedating the furnace described by Siemens. This is probably the first electrical furnace, if you will except the furnace which Hare used in his laboratory in Philadelphia.

But these platinum metals showed serious defects aside from their high cost, and by that time, Weston had become so familiar with the properties of good carbon that like

other inventors, he became convinced that the ultimate success lay in that direction.

Dr. Baekeland then sketched Weston's work on incandescent lamps. The fatal defect of early lamps was structural lack of homogeneity. There would be points with a high resistance and these would burn out.

Weston tried to solve this difficulty by means of his chemical knowledge. He remembered that as a boy, when he went to visit the gas works to obtain some hard carbon for his Bunsen cell, this carbon was collected from those parts of the gas retort which had been the hottest, and where the hydrocarbon gas had undergone dissociation leaving a dense deposit of coherent carbon.

In this chemical phenomenon of dissociation at high temperature, he perceived a chemical means for "self-curing" any weak spots in the filament of his lamp. The remedy was as ingenious as simple. In preparing his filament, he passed the current through it while the filament was placed in an atmosphere of hydrocarbon gas, so that in every spot where the temperature rose highest on account of greater resistance, brought about by the irregular structure of the material, the hydrocarbon gas was dissociated and carbon was deposited automatically until the defect was cured, with the result that the filament acquired the same electric resistance over its whole length.

But this invention, however, brilliant, did not limit his efforts. He had become imbued with the idea that the ideal filament would be an absolutely structureless, homogeneous filament, with exactly the same composition and the same sections throughout its whole length. He reasoned that such a filament could not be obtained from any natural products, neither from paper nor bamboo, but that it had to be produced artificially in the laboratory from an absolutely uniform, structureless chemical substance. After various unsuccessful attempts, he finally secured this result by applying his old knowledge of the days when he used to make collodion. He produced a homogeneous, structureless transparent film of nitrocellulose by evaporating a solution of this material in suitable solvents. As he could not carbonize this film on account of the well-known explosive properties of so-called "gun-cotton," he obviated this difficulty by eliminating the nitrate group of the molecule of cellulose-nitrate by means of ammonium-sulphydrate. This gave him a flexible, transparent sheet, very similar in appearance to gelatine; this material he called "tamidine." Such films could be cut automatically with utmost exactitude, producing filaments of uniform section, which then could be submitted to carbonization, before fastening them to the inside of the glass bulb of the incandescent lamp.

It is interesting to note here that the modern tungsten lamp, in all its perfection, made of ductile tungsten, is after all, the fullest development of the principle of an entirely structureless, homogeneous chemical filament. The tungsten-filament can stand much higher temperatures than carbon and this property gives it higher lighting efficiency, but the former tungsten filaments of a few years ago, which had a granular structure, had the same defect as the earlier carbon lamps, namely, a non-homogeneous texture and correspondent short life.

While Weston was wrestling with all his electrical problems, and more particularly with the construction of dynamos and motors, he was handicapped continuously by the clumsy and time-consuming methods of electrical measurements which were the best existing at that period. Up till then, these methods had been found good enough for physical laboratories, where the lack of accuracy did not result disastrously in hitting the pocket of the manufacturer, or where time—abundant time—for observations and calculations was always available. But progress in the electrical industries lagged behind the delay and uncertainties caused by electrical measurements.

So Weston was compelled to invent for his own use a set of practical electrical measuring instruments. It was not long before some of his friends wanted very badly duplicates of his instruments; before he knew it he was giving considerable attention to the construction and further development of these instruments.

Just about this time the electric light and dynamo construction enterprise entered into a new period where they began to develop in large unwieldly commercial organizations, requiring public franchises and which had to be backed by vast amounts of new capital. In its boards of directors business men or financial men and corporation lawyers became paramount factors and eclipsed in importance the technical or scientific men, who, in earlier days, had almost exclusively contributed to the development of the art.

Following his natural inclinations, Weston soon abandoned his former business connections in order to entrench himself in a field where individuality, science and technology were of almost unique importance, and which he could develop without the necessity of incurring financial obligations beyond what he could master personally. Thus he dropped his connections with the electric light and dynamo enterprises and we see him now, heart and soul, in another new industry which he created—the art of making accurate, trustworthy and easy-to-use electrical measuring instruments. Did he foresee at that time that this art would attain the magnitude to which he has brought it to-day? Did he dream that his early modest shop was to develop into one of the most remarkably equipped factories in the world; an institution which seems the embodiment of what industrial enterprises may look like in future days, when scientific and liberal minded management will have become the rule instead of the exception.

In his factory in Newark, Weston seems to have instilled some of his own reliability and accuracy in the minds of the men and women he employs.

In fact, has it occurred to you that even a man with the widest knowledge and the highest intelligence, who is not scrupulously reliable and careful, who is not the soul of honesty personified, could not make honest and trustworthy measuring instruments nor create reliable measuring methods?

What Stas did in chemistry for atomic weights, Weston did for electrical measuring; he created radically new methods of measurement and introduced an accuracy undreamt of heretofore. Do not forget that his problems were not easy ones. When the British government offered a prize of $100,000 for the nearest perfect chronometer, the problem of a reliable chronometer involved considerably less difficulties and fewer disturbing factors than those encountered in devising and making electrical measuring instruments. But here again, even at the risk of monotonous repeating, I want to impress you with the fact that the success of the methods of Weston was found in almost every case in the application of chemical means by which he tried to solve his difficulties.

When he took up this subject, the scientists, as far back as 1884, accepted implicitly the belief that the definition of a metal and a non-metal resides in a physical distinction; that for metals the electrical resistance increased with temperature, while for non-metals, their resistance decreased with temperature. This was another one of those readily accepted axioms which nobody dared to refute or contest because they were repeated in respectable text-books.

And yet this unfortunate behavior of metals was the greatest drawback in the construction of accurate measuring instruments. Indeed, on account of the so-called temperature coefficient, all measurements had to be corrected by calculation to the temperature at which the observation was made. This seems easy enough, but it was time-consuming and often it is more difficult to make rapid accurate observation of the temperature of the instrument itself. First of all, the thermometers are not accurate, and have to be corrected periodically, and furthermore, it is not an easy matter to determine rapidly the temperature of a coil or instrument. Moreover, by the very passage of the electric current, fluctuating changes in temperature are liable to occur, which would make the observations totally incorrect. All this led to hesitation and slowness in measurements.

Weston wanted to correct this defect, but he was told that the very laws of physics were against his attempts. Before he was through with his work, he had to correct some of our conceptions of the laws of physics; now let us see how he did it:

Weston knew that the favorite metal for resistances was so-called German silver. Strange to say, he was the first one to point out to the Germans themselves that "German silver" is a word which covers a multitude of sins, and that the composition of German silver varies considerably according to its source of supply. The result was that he soon proposed a standard copper- and nickel- and zinc-alloy containing about 30 per cent. of nickel, and which had a resistance of almost twice that of ordinary German silver and a much lower temperature co-efficient.

Not satisfied with this, he took up the systematic study of a large number of alloys. The first batch which he undertook to study amounted to more than 300 different alloys. Since that time, he has considerably increased this number. and is still busy at it. Everyone of these alloys he made himself in his laboratory, starting from pure materials, and controlling the whole operation from the making of the alloy to the drawing of wires of determined size. By long and repeated observations, on which many years have been consumed, he was able to determine the electrical behavior of each one of these alloys at different temperatures.

After awhile, he began to observe remarkable properties

in some manganese alloys he compounded. He managed to produce an alloy which had sixty-five times the resistance of copper. But getting bolder and bolder, he strove to obtain an alloy which had no temperature-coefficient whatever. He not only succeeded in doing this, but finally, produced several alloys which had a *negative* temperature-coefficient. In other terms, their resistance, instead of increasing with rise of temperature, decreased with increasing temperature. He also showed that the resistance of these alloys depended not only on their composition, but on certain treatments which they undergo, for instance, preliminary heating. And since that day, the physicists have had to bury their favorite definition of metals and non-metals. The present generation can hardly realize what this discovery meant at that time. I could not better illustrate this than by reminding you of the fact that in 1892, at the meeting of the British Association for the Advancement of Science, where it was urged to found an institution similar to the Deutsche Reichsanstalt, Lord Kelvin said in his speech:

"The grand success of the Physikalische Reichsanstalt may be judged to some extent here by the record put before us by Prof. von Helmholtz. Such a proved success may be followed by a country like England with very great profit indeed. One thing Prof. von Helmholtz did not mention was the discovery by the Anstalt of a metal whose temperature co-efficient with respect to electrical resistance is practically nil; that is to say a metal whose electrical resistance does not change with temperature. This is just the thing we have been waiting for for twenty or thirty years. It is of the greatest importance in scientific experiments, and also in connection with the measuring instruments of practical electric lighting, to have a metal whose electrical resistance does not vary with temperature; and after what has been done, what is now wanted is to find a metal of good quality and substance whose resistance shall diminish as temperature is increased. We want something to produce the opposite effect to that with which we are familiar. The resistance of carbon diminishes as temperature increases; but its behavior is not very constant. Until within the last year or so nothing different was known of metals from the fact that elevation of temperature had the effect of increasing resistance. The Physikalische Anstalt had not been in existence two years before this valuable metal was discovered."

Then followed this colloquy:

"Prof. von Helmholtz—The discovery of a metal whose resistance diminished with temperature was made by an American Engineer.

Prof. Ayrton—By an Englishman—Weston.

Lord Kelvin—That serves but to intensify the position I wished to take, whether the discovery was made by an Anglo-American, an American Englishman, or an Englishman in America. It is not gratifying to national pride to know that these discoveries were not made in this country."

The misinformation of Kelvin was due to the fact that after the Weston patents had been published, his alloy was called *manganin* in Germany, and quite some publicity had been given to its properties with scant reference to its real inventor, an occurrence which, unfortunately, is not unfrequent not only among commercial interests but in technical or scientific circles as well.

No less important was the invention of the Weston cell, which in 1908, by the international commission for the establishment of standards of electrical measurements, has become the accepted universal practical standard for electromotive force. Here again, this physical standard was obtained by chemical means. . . .

"Dr. Weston assures me that he has succeeded in making his alloys to show only a change of one-millionth for a variation of 1 deg. C. The metallic alloys he discovered are used practically in nearly all kinds of electrical measuring instruments throughout the world. Weston instruments and Weston methods are now found in all properly equipped laboratories and electrochemical establishments of the world. On a recent trip to Japan, I saw them in the University of Tokio, as well as in the Japanese war museum, where their battered remains attested that the Russians used them on their captured battleships. I have worked in several laboratories in Europe equipped with an instrument said to be "just as good" as those of Weston, but in most instances they were imitations of Weston instruments and it was significant that they kept at least one Weston instrument to be used to correct and compare their national product.

"Like many inventors, Weston has been engaged extensively in patent litigation. To uphold some of his rights, he had to spend on one set of patents nearly $400,000, a large amount of money for anybody, but as he told me, he begrudges less the money it cost him than all his valuable time it required—a greater loss to an inventor thus distracted from his work. What is worse, most of this litigation was so long-winded that when finally he established his rights, his patents had aged so much that they had lost, in the meantime most, if not all, of their seventeen years' term of limited existence. And here I want to point out something very significant. In the early periods of his work, between 1873 and 1886, Weston took out over 300 patents. Since then, he has taken considerably less, and of late, he has taken out very few patents, after he became wiser to the tricks of patent infringers.

"Formerly, as soon as he published his discoveries or his inventions, in his patent specifications, he was so much troubled with patent pirates that instead of being able to attend to the development of his inventions, he was occupied in patent litigation. As an act of self-preservation, he has had to adopt new tactics. He now keeps his work secret as long as possible, and in the meantime spends his money for tools and equipment for manufacturing his inventions. In some instances, this preparation takes several years. Then by the time he sends any new type of instruments into the world, and others start copying, he has already in preparation so many further improvements that pretty soon the next instrument comes out which supersedes the prior edition.

"He had to utilize these tactics since he found how impractical it was to rely on his patent rights for protection. That inventors should have to proceed in this way is certainly not a recommendation for our patent system; it kills the very purpose for which our patent laws were created, namely, *the prompt publication of new and useful inventions.*

Dr. Weston's Address

Dr. Edward Weston made a very interesting and thoroughly characteristic address. As he had a cold, he started with a low and hoarse voice, but it grew stronger as he kept on, and he stuck to his subject until he had brought out what he wanted to say. He had no prepared speech, but spoke off-hand. He told delightful reminiscences of his doings with men and customers, how they had to be handled and educated, how early troubles were changed into final successes, and how endless research work had to be kept up to achieve results. This informal way of talking made his speech particularly charming in its personal directness to his audience. But it also deprives us of the privilege of publishing the address now in full. We cannot do better than give a rough outline of his speech at this time.

Dr. Weston said he was glad he had acquired from his work in chemistry that exactness and experience which can only be obtained from chemistry. He had always been together with chemists. He regretted that the specimens of his early chemical and physical work had been packed away in boxes and were therefore not available now.

Dr. Weston first dealt at considerable length with his early work on nickel plating. The public had to be educated and the platers had to learn how to do it. In general there was no difficulty with the solutions themselves. The trouble was mainly in the use of methods that were employed in the deposition of silver, thus overlooking the fact that silver is soft and nickel is hard. Dr. Weston explained in detail what this difference meant and dealt especially with the methods of cleaning and the substitution of chemical for mechanical cleaning.

During this work Weston got impressed with the fact that nickel is hard, and asked himself whether it would be possible to get softer nickel. He found indeed a method of depositing "malleable nickel" that can be rolled. In this connection Dr. Weston discussed at length the problem of single salts versus double salts.

Dr. Weston recited various cases of troubles, especially the fact that when a single salt is used, first a good deposit is obtained, but after a time it loses its white color, gets darker and assumes a green tint and hydrogen is evolved. This is due to the fact that the solution becomes more and more basic. As soon as acid is added, the deposit becomes all right again.

Weston's work on nickel finally led him to the invention of a new nickel anode and a new nickel solution.

From nickel plating Dr. Weston turned in his address to dynamo design. His first dynamos were built for the plating business and again the platers had to be educated. Dr. Weston told amusing instances of what this meant. Of course, the high first cost was the objection. Weston changed and improved the designs many times,

one of his principal objects being to build cheaper machines.

Dr. Weston then discussed his work on the arc lamp. The cost of imported arc lamp carbons was then $1.20 a dozen when delivered here; that was the reason why he started the manufacture of carbons. In his further work he wanted to change the color, but also wanted to get more light per horsepower. Further he wanted to steady the arc. This led him to the invention of the flaming arc.

When he turned to incandescent lamps, the "subdivision of light" was under considerable discussion. With arc lamps the problem was mechanical, one of regulation. With incandescent lamps a very complicated chemical and mechanical problem was to be solved, and the chemical problem was very severe.

The total resistance of the lamp filament must have a uniform value in all lamps. But this is not enough, since it is necessary that the resistance be uniform all along the length of the filament. In the early filaments, for instance, those made from paper, this was not the case, the fibres being arranged crosswise in all directions. The filament would have high-resistance spots which would burn through. Weston solved this problem by heating the filaments electrically in hydrocarbon vapor whereby a deposit of carbon would form faster on hot spots than elsewhere. This method solved two problems. One was to get the resistance uniform all along the length. The second was that by carrying this operation on long enough it was possible to give to the filament exactly the desired total resistance.

At this point of the address the fighter in the man Weston showed himself in a very characteristic and interesting manner when he discussed the invention of this chemical control of resistance and the fact that the courts had ruled against him in this case.

But the fundamental problem of getting a perfectly uniform structureless filament was later solved by Dr. Weston in another way by extended chemical research. (See Dr. Baekeland's paper above.)

Dr. Weston then gave a review of his work on alloys, starting with German silver and then extending to many hundreds of different alloys. The chief object of this research was to get alloys with the desired resistivity and temperature coefficient for measuring instruments. Manganese is the chief resistance-giving element, nickel comes next. But chemical composition is not everything, since the temperature coefficient depends also on the heat treatment, whether the wire is hard-drawn or annealed. For each alloy it was, therefore, necessary to find the correct heat treatment. This was illustrated in an interesting way by curves exhibited in diagrams on the wall.

Dr. Weston finally spoke briefly of the invention of his standard cell and how he came to use cadmium sulphate.

Dr. Hering's Address

The final address on the program was by Dr. CARL HERING on "Some of Dr. Edward Weston's Achievements in the Field of Electricity."

It is not an exaggeration to say that the rapid development of the electrical industry is in no small part due to the direct-reading electrical measuring instruments which he contributed to the art, and which were of such a high order of accuracy, constancy, reliability, portability and simplicity of application, that it became not only possible but even quite easy to make really reliable measurements, whereby progress in the electrical industries was greatly facilitated. It may be said that the whole space of a room of a laboratory equipped with instruments, has now been reduced by him to a couple of coat pockets, in which the instruments for such measurements may now be carried.

Having myself been engaged in electrical work in that early and trying period when measuring instruments were so sorely needed, as so much of importance had to be discovered by measurements of currents and voltages, and when all but the crudest of these measurements were tedious, difficult, complicated and unreliable, and were generally limited to the use of the laboratory galvanometer, I can personally vouch for the statement that the advent of the Weston instruments marked a turning point in the development of the electrical industry.

More than that, it was a matter of even national interest, for prior to that time the "precision" instruments (in name though not in fact) were imported from abroad. Europe was ahead of America, but now Weston has turned the tables, Europe imports large quantities of these instruments from us. Some years ago, in a visit to the German Reichsanstalt where some of the best research work in the world was being done with the best instruments the world could produce, I noticed, with no little national pride, that Weston instruments, made in America, were in universal use there, and this, in that one of all the European countries which prided itself most for its development of the instrument art.

He early realized that in the successful manufacture of many of the articles used in the electric industry, especially when made on a large scale, such as incandescent lamps, it was essential that reliable and accurate electric measurements be made quickly and by inexperienced labor; he argued that such measurements should be as easy to make as those with the foot rule and the balance. Though considered utopian in those early days, he persisted and finally succeeded in accomplishing it; the accurate measuring of amperes and volts became as simple as reading the dial of a spring balance, and the accuracy and reliability greatly exceeded it. Indeed it may be justly said that he created the art of practical electrical measurements in the industries, with direct reading, portable instruments requiring no trained experience, to a degree of accuracy equal to and often exceeding that formerly obtained with far more complicated apparatus in laboratories, by skilled and experienced men.

One of the essential factors in making such rapidly repeated measurements in the manufacturing industries, was the avoidance of having to make the troublesome correction calculations, such as those due to changes of temperature. As existing metals and alloys were very inadequate in this regard, for resistance materials, on account of their temperature corrections, Dr. Weston, with the determination, persistence and indefatigability which are so characteristic of all his work, and with rare courage in attacking especially difficult problems, set himself the task of finding something better, and as usual he succeeded, giving to the world the alloy now known as manganine, a copper, manganese, nickel alloy, which combined the two very desirable features of a very small temperature coefficient and a high resistivity. The importance of this alloy is shown by the fact that it is now used and adopted internationally. Though the Germans for a time claimed priority in its discovery or invention, they seem now to give him the credit, even to the extent of suggesting calling it "Westonine."

Having succeeded in what he was determined to find or produce, Dr. Weston does not rest, as most men do; on the contrary, he at once starts to get something still better; he is his own strongest and most determined competitor. The world was glad to get manganine, but he wanted something more; he wanted an alloy of practically no temperature coefficient, and having then gotten this, he wanted still more, a negative coefficient, something which there was no reason to think existed. As usual, he succeeded in producing it, but still was not satisfied until he had found several of them. The vastness of this metallurgical research will appeal to one when it is considered that there are quite a number of available metals, and that the various possible combinations of these in groups of two, three, four and more in different proportions, is practically infinite.

Nor did it satisfy him to find an alloy that had this desired quality, as it would be useless if it could not be drawn into a wire. Many of these alloys were stubborn and various thermal and mechanical operations had to be found before these otherwise desirable alloys could be made to yield to the wire drawing process. The thermo-electric properties when in contact with other metals also were an important factor and added to the complications.

The best standard cell known in those early days, for serving as a concrete voltage standard, was not considered by him to be up to his standard of ideals, and indeed it was a troublesome apparatus to use; so he gave himself the task of producing a better one; one which was more easily reproducible and had a lower temperature coefficient; the fact that many others all over the world had tried it but were unsuccessful, rather encouraged than discouraged him. As in other problems which he undertook, he succeeded, and gave to the world something far better

than the best it had had, and the world recognized it by making it the international standard; even the Germans now call it the Weston standard cell, though for years they contested the priority of invention. Its predecessor, the Clark cell, is now fast finding its way to the shelves of the museums.

Not satisfied with this standard of reference in which the solution was saturated at all temperatures, he also produced a working cell, the so-called unsaturated one, which saves the user some correction calculations, as it has a still better temperature coefficient.

That his instruments were ranked by electrical engineers as of the highest standard is best shown by the fact that the highest claim that competitors could make was that their instruments were "as good as a Weston," whether true or not. It was the pride of laboratories to be equipped with Westons. Disputed measurements were settled by using Westons. When a particular measurement was difficult or troublesome to make, Weston was appealed to to make an instrument to do it easily. Even electrical capacities can now be measured with a portable, direct reading Weston dial instrument, and perhaps a like simple method of measuring inductances will come next. So great was the demand that his list now includes about 4500 different types and ranges of instruments.

Though the credit for developing the fundamental, typical Weston instrument was disputed for years, the patent courts have given sweeping decisions in his favor.

Dr. Hering then discussed at some length Weston's work on dynamo design, on illumination by the flaming arc and by electric incandescent lamps and concluded his address as follows:

Nothing was good enough for him if there was any possibility of improving it, and nothing seems to be too difficult for him to undertake. When the best manufacturers of this country or abroad, including the finest watch makers, found it too difficult to meet his exacting requirements for some of the parts of his instruments, he undertook the task himself. To beat the best gave him pleasure. When he wanted a wire drawn to half a mil in diameter he made it himself, as no manufacturer would undertake such a task. He wanted a screw thread of 500 to the inch, on a 10 mil rod; no one had come more than half way to this, but he accomplished it, originating the taps and dies himself. Not very long ago machine work to a thousandth of an inch was considered the highest class of work, but this was not good enough for Weston, who now works to the millionth, one thousand times finer.

A characteristic of his work is that he insists upon completely finishing a piece of work in the privacy of his laboratory, before it is brought before the public, which is in marked contrast with the more usual course of publicly proclaiming in the daily press the great things one intends to do, and which often never materialize. Instead of selling futures he sold finished products. His high ethical principles were shown when in the early days of incandescent lighting he insisted on the equity of rating the lamps by their mean spherical candle power, instead of deceiving the purchasers by measuring them in the direction of maximum light, as was not infrequently done by others.

Among his other early achievements may be mentioned the use of an arc furnace in 1875-6 for melting platinum and iridium, hence prior to Siemens, whose arc furnace is usually cited as the first. Dr. James Douglas, who was the first in this country to refine copper electrolytically on a large scale, credited his success to the advice and assistance of Weston in 1878, when very erroneous ideas about its practical impossibility were prevalent among others.

His personality only those of his personal friends who have had the good fortune to have been guests at his home and have been intimately associated with him, can truly appreciate. The same laudable extremes to which he aspires in perfecting his products, he shows in his kindness and loyalty to his friends and associates, as also in defending himself against his enemies. His high ethical principles have made for him both staunch friends and bitter enemies. To profit from losses to those who have shown confidence in his work is repulsive to him; what gives him pleasure is to please them.

On whatever balances a man's life work may be weighed, the scale of last resort for measuring it is the question, "In what way has the world benefited by his having lived in it?" The summary of his work, as given here to-night, will answer this.

The whole evening was very enjoyable, though the proceedings extended to a very late hour. The former recipients of the Perkin medal were Sir William Perkin, J. B. F. Herreshoff, Arno Behr, E. G. Acheson, C. M. Hall, H. Frasch, James Gayley and J. W. Hyatt.

Pyritic Smelting at Mount Lyell

At a recent dinner of the New York section of the Mining and Metallurgical Society of America, Mr. **Robert Sticht**, general manager for the Mount Lyell Mining & Railway Co., Queenstown, Tasmania, spoke informally of his experience in pyritic smelting in that country during the past 20 years. His remarks were discussed in an interesting manner by several members of the Society. Mr. Sticht said in part:

"As regards smelting, when I arrived at Mount Lyell the pyrite method was still a problem. I had enjoyed opportunity to carry it out in its purity, for short periods, whenever the ores were suitable, in Montana and Colorado, and had no fear, on an empirical basis, that it would not be possible to carry it on continuously where the ore was so favorable as at Lyell. But, for my own satisfaction in fully understanding what went on inside of a furnace, I was made general manager too soon. I then had to look after the pounds, shillings and pence, and investigations of metallurgy, as such, had to be postponed.

"Briefly, we started with three blast furnaces in 1896 and then installed converters. This plant was gradually enlarged to six blast furnaces. A second plant was built with five furnaces. When we abandoned hot blast, after six years' use, we pulled down the first plant and did all the work in the second. This plant received an extra furnace in the course of time, so that it has six, but we usually run only three furnaces. The most interesting development, perhaps, was the discarding of hot blast. I do not think I would now recommend it under any conditions.

High Ore Column and Blast Pressure

"Our furnace column reaches 18 ft. above tuyeres, and we use 64 oz. blast pressure. We base our work on the assumption that the inside of a furnace is occupied by a honeycombed mass of quartz, the passages of which are traversed by the blast and the molten sulphide, in opposite directions, the incandescent silica effecting simultaneous oxidation of the latter, by the oxygen of the blast, and the union of the FeO, thus formed, with the silica itself. This forms the slag, while the unoxidized portion of the sulphide makes the matte. Our matte runs from 45 to 50 per cent., rarely under 35 per cent., and sometimes as high as 60 to 65 per cent. (a 20:1 concentration). When the matte becomes too high, we reduce the siliceous ore; when too low, we increase the latter. The proportion of pyrites in the charge is constant; also the limestone. The only variables are siliceous ore and coke, but the latter is changed much less frequently than the former.

"As regards the percentage of coke used, I regret to say that the time when we got along with only 1½ per cent. (and sometimes as little as 1/10 per cent., with hot blast) is now merely historic. We are now under the necessity of smelting more of the siliceous ore, and, at the same time, the iron and sulphur in the pyritic ore have diminished, owing to the inclusion of a little galena and zinc-blende and a little more gangue. As a consequence, we now employ from 3½ to 5 per cent. coke, figured on the materials charged (except coke). The coke is our own make, but high in ash, and wet from the rainfall, which is 110 in. annually. Our slags are also more siliceous than they used to be, averaging 35 to 37 per cent. SiO_2 as against 30 to 32 per cent. in the past. The campaigns used to be three months or less; now they are a good deal longer, easily six months, the stoppages being caused by leaky jackets or the forehearth.

"Concerning shape of bosh, I am unable to see that it makes any difference. The furnace creates its own

internal lines, which may be entirely different from those of the designer. One can alter the position of the smelting zone, i. e., the focus, by changing the blast. The focus can be driven up by increased blast, in fact it may be driven clear to the top of the column.

"You might think our works old-fashioned. We have kept fully in touch with all modern improvements and tendencies in the United States, but have not found that we could advantageously make use of the most striking ones. This is true as well of economic as of purely metallurgical points. Each furnace is run individually as regards momentary composition of charge, and the principal factor in their operation is the feeding. We have to be very particular about this, and cannot resort to mechanical appliances intended to serve unchanging average conditions of feed, because our process is so sensitive to variations in the relative proportions of silica, sulphide, and air, and to the physical way in which these three come together. You cannot run a number of pyritic furnaces all in the same manner and obtain our present grades of matte with satisfactory constancy. You would have to reduce the grade to, say 20 per cent., and be satisfied to re-treat this."

Mr. D. H. Browne called attention to the fact that the practice outlined by Mr. Sticht was not applicable to all ores which contain sufficient iron and sulphur to smelt them. Sudbury ores, for example, containing 35 per cent. iron and 20 per cent. sulphur, are theoretically amenable to pyritic treatment, but many attempts had been made without success.

Experience at Tennessee Copper Company

Mr. J. Parke Channing said: "About 15 years ago, when I was starting the operations of the Tennessee Copper Co., I heard of what Mr. Sticht was doing at Mount Lyell, in Tasmania, and Mr. Frank Klepetko kindly laid my problem before Mr. Sticht. He advised me that I had better not begin with pyritic smelting in Tennessee, but stick to heap roasting. We spent $70,000 putting in roast yards, then smelted the ore with 13 per cent. coke, making a 40 per cent matte in the first operation, which was then converted We made money, and everyone was satisfied. I fear that if we had started on pyritic smelting I might have made a failure of it.

"Shortly after this, Mr. Freeland, manager of the Ducktown Sulphur, Copper & Iron Co., whose property adjoined that of the Tennessee Copper Co., began pyritic smelting. At first his slags were too siliceous, and to correct them he tried adding iron ore. This only made matters worse; and eventually, after pounding away at it and trying all the various combinations, he found that what was necessary was to cut down the coke and add silica. To him is due the credit for the pioneer work in pyritic smelting in the Ducktown district.

"Having the benefit of his experience, I took one of our 56x180-in. furnaces, ran the ordinary roasted-ore charge down low, filled it up with the pyritic charge, with a minimum amount of coke, and the furnace ran perfectly. We found, however, that it did not make much better than 10 per cent matte, which was then concentrated in a second furnace and bessemerized. We were soon able to clean up the roast yards and operate entirely by the pyritic method. Incidentally, we noted an increased extraction, as apparently some inexplicable loss ocurred in the roast yards, which we were never able to trace. We were never able to reduce the coke so far as Mr. Sticht did, nor were we able continuously to get so high-grade matte as he. As the furnaces are now operated, the question of matte-fall is of secondary importance, the most important object being to produce a gas which can be used in the acid chambers for the production of sulphuric acid.

"The present aim is to yield a gas which will run about 6 per cent SO_2 and 9 per cent free oxygen, so that there may be enough oxygen to convert the SO_2 to SO_3 in the chambers. If the SO_2 is high, and the oxygen low, it will not do to add atmospheric air, because of the large amount of nitrogen thereby introduced, which dilutes the SO_2 below working requirements. The best way is to keep the coke down to a small amount so that too much of the free oxygen will not be consumed in burning this carbon.

"For many years I had maintained to Mr. Browne that there was no reason why he should not smelt the Sudbury ores pyritically. He haunted the works of the Tennessee Copper Co. for over a year, trying to learn how to do it. About two years ago he engaged Mr. George A. Guess, who had been in charge of the Tennessee smelter, to try the experiment at Copper Cliff. Mr. Guess was given a furnace and blowing engine, and any kind of ore and flux that he wanted. After about three months I received two letters in the same mail; one from Mr. Browne saying that Mr. Guess had given it up, and the other from Mr. Guess himself saying that he could not smelt the ores pyritically and did not know why.

"I have grave doubts whether nickel-copper ores can be smelted pyritically. Possibly there is some peculiar characteristic of the nickel sulphide which prevents the pyritic action from taking place. In addition, a large amount of the silica in the Sudbury ore is combined as a bisilicate, and the conditions in the furnace are not suitable for breaking up this combination. There is just a possibility that in a very high furnace the desired result might be obtained, though I am of the opinion that Mr. Browne will have to continue with his roast heaps, for the present at least. There is a possibility that in the Knudsen furnace the problem may be solved. There, none of the material can get away, and possibly the complicated reactions may take place."

Action of Pyrite and Pyrrhotite

Mr. Sticht was asked whether the difference in the action of the Australian and Sudbury ores might not be due to the fact that the former was a pyrite and the latter a pyrrhotite, the extra atom of sulphur in the former exercising a favorable influence on pyritic treatment. In reply, Mr. Sticht said that he believed there was a strong misconception regarding the utility of the extra atom of sulphur in pyrite as a source of heat in the pyritic process. This extra atom is not burned, but is distilled. The FeS_2 turns practically to pyrrhotite at once, and even to something like Fe_2S_3 or Fe_4S_5 in the lower part of the furnace, and it is this particular sulphide which supplies the heat. In many ways, I think, a pyrrhotite ore is probably easier to smelt than a pyrite ore, but I may repeat that the most essential condition for the process is to have *free* SiO_2. What experience I had with pyrrhotite ores in Colorado made me feel that they were easier to treat than pure pyrites. In addition to keeping the throat more free, they seem to run hotter. But it was necessary not to be afraid to reduce coke, i. e., to a minimum which would ordinarily seem dangerous.

"One ought to have several feet leeway in the height of his smelting column. In reconstructing the Mount Lyell works, I raised the charge floor eight feet above the former one. A separate blower for each furnace is desirable if one can afford it, but that is only a minor point when there are not too many furnaces. When formerly using hot blast, the stoves standing between

blowers and furnaces, it complicated matters to have a blower for each furnace, and we did not do that at Mount Lyell. Our practice now is to supply about 20,000 cu. ft. of cold, free air per minute to each furnace. The 64 oz. pressure is only an incidental feature of the blast, and is due merely to the resistance encountered in forcing a given volume of air through a certain size of tuyere in a given time. Roughly speaking, it is volume rather than pressure that counts.

No Oxygen in Furnace Gases.

"Regarding the composition of our furnace gases, since the figures were first published, we have occasionally repeated the analyses, and still find practically no oxygen in the gases leaving the furnace, nor at a depth of 7½ ft. below top of the column. The determinations were last made a few months ago, with a water-cooled apparatus."

"The furnaces at Mount Lyell appear to be running with hot tops. This is due to the large amount of sulphur distilling off, which burns as it comes in contact with oxygen of the air above the charge. It is possible to run the furnace on matte and pyrrhotite with a satisfactorily cold top. On pyrites, however, this is impracticable, for this low temperature can be achieved only by operating in a manner which leads to rapid formation of crusts around the throat. We run, therefore, so as to avoid crusts, and thus appear to have a fiery throat. One must, however, not contemplate the combustion of the sublimated elemental sulphur, but judge throat conditions rather by the phenomena at the top of column. The top of the furnace is really not hot, for the pieces of charge glow slightly only around the walls, and are black and cold over the full inner area of the top. Between these cold pieces a whitish flame is visible, which changes into a heavy cloud of sulphur vapor a foot or two above the top of charge; this then ignites and forms the usual dense white smoke characteristic of the work. The furnace acts as its own crusher; all materials are charged in as massive lumps as the men at the mines and quarries can readily handle. Possibly, if we crushed them first, they would so decrepitate in the furnace that the latter would choke tight, and we could not practice pyritic smelting."

Synopsis of Recent Chemical and Metallurgical Literature

Gold and Silver

Improved Cam for Stamp Mills.—In the December *Bulletin* of the A. I. M. E., Mr. Arthur B. Foote describes an improved form of cam which he has used at the North Star mill in California.

"The cam at present in use lifts the tappets with an involute form of curve, to which the surface of the tappet is always tangent. Moreover, the line of contact between tappet and cam, if produced, would pass through the center of the stamp. While this is a desirable feature, the inventor had believed that it would be more desirable if the cam were to pick up the stamp without shock, and gradually increase the upward velocity throughout its movement. The involute cam attempts to impart instantly a high upward velocity to the stamp, starting it from a state of rest, and the result is a destructive blow, a good deal of noise, and much wear and vibration.

"The new form is one which is designed to lift the stamp with a motion similar to that of the piston of an engine between the end and middle of its stroke; in other words, harmonic motion, from the point of zero to maximum velocity. The curve will give this ideal motion only when the stamp is set for the exact drop for which the cam was designed, but the improved cam will not be as bad as the involute until the drop is reduced one-half. In other words, if a cam is designed for a 6-in. drop, it will be some improvement over the usual form of cam until the drop is only 3 inches.

"Any cam, of course, must lift its stamp in the same number of degrees of revolution, and therefore this new form, starting the stamp slowly, must end up by going faster, the average speed being the same. With this design, the surface of the tappet is not tangent to the surface of the cam throughout the lift. The possible consequences of this were studied with a full-sized model, and did not seem serious, since the engagement between the surfaces was an easy sliding motion instead of a blow. If the drop is shortened, the blow becomes more and more pronounced, but the surfaces also become more and more nearly tangent.

"Five cams of this design have been running in one of the mills of the North Star Mines Company for over a

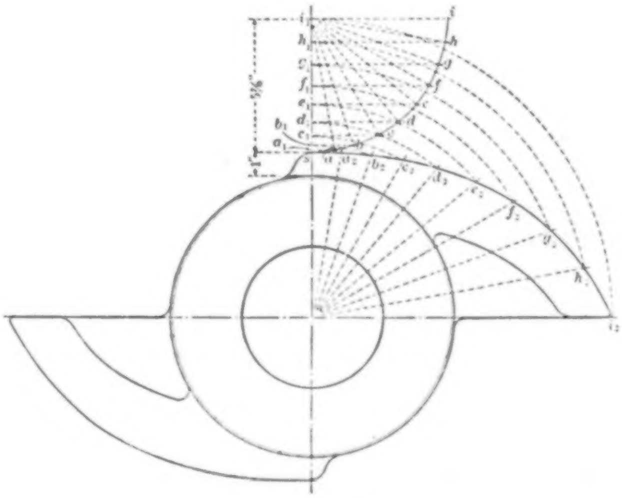


FIG. 1—IMPROVED CAM

month, fulfilling every expectation. Holding the hand on the tappet it is impossible to feel the cam strike it, although the mill is running 107 drops per minute.

"The accompanying drawing, Fig. 1, shows the method of laying off the curve of the cam, which will give approxiately harmonic motion to the stamp. The spaces sa_1, a_1b_1, b_1c_1, etc., represent the distances traveled by the cam in equal intervals of time."

Acid Treatment of Gold Precipitate.—Some practical notes on this subject are offered by Mr. H. A. White in the September, 1914, *Journal* of the Chem. Met. & Min. Soc. of S. Africa. The use of sodium bisulphate is becoming general in place of commercial sulphuric acid. This material is obtained as a byproduct from dynamite factories, and contains from 28 per cent to 40 per cent sulphuric acid. Its use shows a saving over commercial acid.

"Where white precipitate is present in the boxes in considerable quantity, special precautions are advisable in the acid treatment. These include (a) emulsification of the white product taken from the filter press and the avoidance of the formation of greasy lumps which are very slowly acted upon by the acid. (b) Owing to the fact that the action of sulphuric acid is somewhat slow (especially in the presence of ferrocyanides) it is advisable to allow at least twelve hours' contact with hot acid in excess and to reserve some of the coarser zinc shavings, to be dissolved, for subsequent neutralization of the remaining acid. A considerable improvement in the value of the calcined slime is easily effected in this way."

The corrosion of the clay liners used in crucibles is observed to increase rapidly in the vicinity of cracks. In order to avoid the formation of these cracks it is essential that the liner should be evenly supported and heated. To attain this object it is well to fill the space between the liner and pot with powdered graphite, using crushed crucibles for this purpose. Liners supported in this manner will give up to 50 per cent more fusion than usually obtained.

"On some mines it is not found necessary to add any flux or oxidizer whatever to the well-calcined gold slime as it is self-fluxing and contains sufficient ferric oxide to keep the value of the bullion produced well above the level of the usual battery bars. The slag thus produced is fairly low in gold, but owing to unavoidable variations in the composition of the calcined slime, even on the same mine, trouble may be caused by insufficient fluidity of the slag or by undue corrosion of the liner.

"A method allowing a little more elasticity in conditions is to fill the liner within ½ in. with the gold slime and to pour on this, as a protective cover, a mixture of 1½ parts of fine sand and 1 part (by weight) of calcined borax. This may amount to 15 per cent or 20 per cent by weight of the calcined gold slime, and gives a fluid non-corrosive slag at a reasonable heat. I would suggest that preliminary experiments in this direction be made with two of the pots in a "pour," as any trouble can easily be rectified (by adding borax or otherwise) in the next melt, and the conditions are strictly comparable.

"It is clear from comparative experiments made with slime ranging in value from 10 per cent to 35 per cent of bullion that, as Mr. Dowling has pointed out (*Rand Metallurgical Practice*, Vol. I, p. 271, and *Chemical, Metallurgical and Mining Society's Journal*, Vol. VII, p. 212, January, 1907), the intimate mixture of flux and slime is not necessary, and this practice, which is conducive to loss of valuable dust, should by now be completely obsolete.

"By the above methods the value of the gold slag produced (after panning) may be reduced below 10 oz. per ton, and as the quantity is smaller the total value of such by-products as pots, liners, and slag should not exceed ½ per cent of the cyanide gold produced, and, in fact, in some cases is below ¼ per cent, while the buttons of gold from each pot have averaged over 100 oz. for some clean-ups. In this manner also a considerable saving in cost is shown."

Determining Dissolved Gold in Slime Residue.—Since vacuum filtration of slime became common practice, it has become increasingly necessary to know definitely the gold content of slime residue in order to regulate the dissolving and washing periods and secure the highest economic extraction. In a paper published in the monthly *Journal* of the Chamber of Mines of Western Australia Mr. L. R. BENJAMIN discusses the methods for determining the proportions of soluble and insoluble gold in filter residue, and points out possible errors in the work.

One method is to filter and assay the solution in the residue, and calculate the equivalent of dissolved gold from the percentage of solution to dry slime. The value thus obtained is then deducted from assay value of dried residue, giving the undissolved equivalent. Another method is to assay the dried residue for total gold; assay the water-washed residue for dissolved gold and get the undissolved equivalent by difference.

The author discusses the possibility of gold losses by either of these methods and finds two periods in the operation when high temperatures may cause loss of gold and affect the accuracy of the work. The first period is in the drying of the sample over a fast fire, when he finds that capillary attraction may cause a segregation of gold into a scale adhering to the pan. The second is during the assay fusion.

He found air-drying to yield higher results than fire-drying, but requiring a longer time for the work. In order to minimize the losses in rapid drying he suggests precipitating the dissolved gold prior to drying, and finds that the use of a 5 per cent cuprous chloride solution gives excellent results. As for fusion losses during assaying, he comes to the conclusion that they are "anything but a bogey," and always occur, varying directly with the amount of gold remaining in the combined state after drying, and due probably to volatilization.

Copper Smelting.

Coal-Dust Fired Reverberatory Furnaces.—In the January *Bulletin* of the American Institute of Mining Engineers there are two papers on the development and use of coal-dust firing for reverberatory copper smelting. The first, by Mr. D. H. BROWNE, reviews the history of the method and its adoption at the works of the Canadian Copper Company; the second. by Mr. L. V. BENDER, gives results obtained by the Anaconda Copper Company.

The use of reverberatory furnaces at the Canadian Copper Company's works was made necessary by increasing quantities of flue dust and fine green ore. When the practice was first considered, coal-dust firing was investigated and considered feasible. S. S. Sorensen had been the pioneer investigator in this line of work at the Highland Boy smelter in Utah, and had been followed by Charles Shelby at Cananea. Both had experienced trouble due to accumulations of ash as a blanket on the molten charge and in the throat of the furnace, but the trials indicated possible improvement in reverberatory smelting, particularly as regards fuel ratio. It was finally adopted at Copper Cliff, however, designing furnaces especially to meet the requirements by eliminating right-angled bends in the flues and placing the skimming door at the side instead of the end. The waste-heat boiler was made a secondary consideration. The first smelting showed no difficulty with the fuel, and as improvements were gradually made the smelting became more efficient. In the first three months of 1914 the fuel ratio was 5, 5.65 and 6.77, respectively. The method of feeding has been changed. At first it was done through hoppers near the fire end, but is now done almost entirely through pipes in the side walls. Coal dust is introduced through five pipes 5 in. in diameter. It is first dried and then ground so that about 95 per cent passes a 100-mesh and 80 per cent passes a 200-mesh screen. The great advantage found in this method of firing is the absence of breaks in the temperature curve due to grating or cleaning the hearth, and as a consequence a greatly increased tonnage and fuel ratio.

At Anaconda coal-dust firing was tried in June, 1914, in a furnace 124 ft. by 21 ft. The method of charging was similar to that used at Copper Cliff. From the experience gained in this work, Mr. Bender lays down the following requisites for successful use of coal dust: (1) The coal should be dried before pulverizing, containing not more than 1 per cent moisture; (2) fine pulverization affords increased area and higher thermal efficiency, 95 per cent should pass a 100-mesh screen and 85 per cent a 200-mesh; (3) the quantities of coal and air delivered to the furnace should be carefully controlled in order to secure complete combustion; (4) the coal should contain enough volatile combustible matter to give the required combustion, a standard for cement work is 30 per cent; (5) the furnace should be properly designed and equipped, and (6) provision must

be made for taking care of the ash. Based on past experience, some changes will be made in the new equipment for coal-dust reverberatory firing at Anaconda. The furnaces will be 144 ft. by 25 ft., with a flue area of 48 sq. ft. Matte will tapped at the front. The skimming plate will be 12 in. higher than in other furnaces, the top of the plate being 24 in. above the tap hole. Recent records for a week at Anaconda indicate the efficiency of coal-dust firing; the average tonnage per day was 542.7, with a fuel ratio of 7.5.

Concentration.

Flow of Sand and Water Through Spigots.—It is common practice in ore-dressing operations to pass pulps of sand and water through spigots, as in jig hutches, classifier pockets, etc. "With a given quantity of solids per unit time, of a given specific gravity, to be discharged with water under a given head, and with a given rato of water to solid, what must be the size of the spigot opening?" Such is the nature of a problem investigated by Prof. R. H. Richards, of Boston, Mass., and Mr. Boyd Dudley, Jr., of State College, Pa. Their results are published in the January *Bulletin* of the A. I. M. E. If a spigot is to be opened continuously, there are, aside from its form, three factors governing the rate at which it will discharge a given mixture, viz., the head of water above the spigot, the area of the spigot opening and the viscosity of the material discharged. By the term viscosity as used here is meant the ratio of the volume of pure water that will flow through a given orifice under a given head in a given time to the volume of the material under consideration that will flow through the same orifice under the same conditions.

The head of water above a spigot is usually fixed; so with the head known, in order to determine the size of the spigot required, it is necessary to know the viscosity of the desired mixture, and the coefficient of discharge of the form of spigot employed when pure water is discharged. From these data the area of the spigot can be calculated from the equation

$$a = \frac{fq}{c\sqrt{2gh}}$$

in which a is the area of the spigot opening, f being the viscosity of the mixture, q the rate of discharge by volume, c the coefficient of discharge, g the acceleration due to gravity and h the head of water above the spigot. The coefficient of discharge is the ratio of the actual rate of discharge of pure water to the theoretical rate as calculated from the effective head above the spigot. The value c for forms usually found in classifier spigots under heads of from 1 to 3 ft. is between 0.87 and 0.91, the higher values for lower heads.

The authors studied the relation between the composition and viscosity of sand-water mixtures. The sp. gr. of the sand was 2.72. Experimental results are given in the table.

Relation of Composition to Viscosity of Mixtures of Sand and Water

Kilos sand and water	Kilos sand	Kilos and litres water	Litres sand	Litres sand and water	Per cent sand, vol.	Per cent sand, weight	Viscosity mixture
9.20	0.00	9.20	0.000	9.20	0.00	0.00	1.00
9.30	0.45	8.85	0.165	9.02	1.83	4.84	1.02
9.35	1.10	8.25	0.405	8.66	4.68	11.8	1.06
9.35	1.40	7.95	0.515	8.47	6.08	15.0	1.09
9.40	1.90	7.50	0.699	8.20	8.53	20.2	1.12
9.40	1.95	7.45	0.717	8.17	8.78	20.8	1.13
9.55	2.20	7.35	0.809	8.16	9.92	22.0	1.13
9.20	2.25	6.95	0.827	7.78	10.6	24.4	1.18
9.05	2.50	6.55	0.920	7.47	12.3	27.6	1.23

It was found by these tests that when the amount of the sand in the mixture exceeded 30 per cent by weight, the spigot would produce a very thick discharge for a short time, but that continuous operation under these conditions was not certain, and clogging would result.

A concrete example illustrating these data is given. It is desired to discharge from the pocket of a classifier 40 tons of sand per 24 hours, together with water in the ratio of 1 sand to 3 water, by weight. The head of water above the spigot is 3 ft. The mean sp. gr. of the sand is 2.81. What must be the diameter of the spigot opening? The area of the opening can be calculated from the formula given.

Taking up the terms on the right hand of the equation is order, f, the viscosity, may be estimated as follows: The weight-ratio of water to sand in the mixture to be discharged is 3 to 1. Considering 100 g. of the mixture, the weight of water is 75 g.; its volume is 75 cc. The volume of the sand is 25 g. $\div$ 2.81 (the density of the sand) = 8.9 cc. The total volume of 100 g. of the mixture is 75 + 8.9 = 83.9 cc. Hence, the percentage of sand by volume in the mixture is 8.9 $\div$ 83.9 = 10.6. From the table the viscosity of a mixture containing 10.6 per cent of sand by volume is 1.17. Therefore $f = 1.17$.

The quantity of sand discharged per 24 hr. is 40 tons. One ton per 24 hr. is 0.631 kg. per minute. Forty tons per 24 hr. is 40 $\times$ 0.631 = 25.2 kg. per minute. The volume of sand per minute is 25.2 $\div$ 2.81 (the density) = 8.98 liters. The quantity of water per minute is three times that of the sand, 25.2 $\times$ 3 = 75.6 kg. = 75.6 liters. The total volume of sand and water per minute is 8.98 (sand) plus 76.5 (water) = 85.5 liters. The total volume per second is 85.5 $\div$ 60 = 1.43 liters = 1,430 cc.

Since the spigot is to consist of a short tube with a cone mouth on the influx end, the coefficient of discharge, c, may be assumed as 0.88.

In metric units g = 980 cm. per sec.²; and the head, h (3 ft.), is 914 cm.

Substituting these values in the above equation gives, for the area of the spigot opening.

$$a = \frac{1.17 \times 1430}{0.88\sqrt{2 \times 980 \times 914}} = 1.42 \text{ sq. cm.}$$

The diameter may be obtained from the relation,

$$d = 2\sqrt{\frac{a}{\pi}} = 1.35 \text{ cm.} = 0.53 \text{ in.}$$

Recent Chemical and Metallurgical Patents

Iron and Steel.

Briquetting Fine Ore.—According to the specifications of a patent of Wilhelm Schumacher, of Osnabrück, Germany, the compression of finely divided iron ore, in which the iron is in a low state of oxidation, together with a catalytic agent such as calcium chloride, effects the conversion of the iron compound into a higher state of oxidation, and produces briquets suitable for use in the blast furnace. The inventor has observed that when flue dust, containing the lower order of iron oxides, is briquetted with a catalytic agent, sound briquets are produced; and further the iron becomes oxidized. In the light of these facts, he proposes to briquet fine iron ores by first reducing them with coal dust, then mixing with lime if necessary, and briquetting. The mixture of ore and coal is heated to 500° or 600°C.; or to a lower temperature, say 400° to 500°C., at which temperature it may be treated with gases containing carbon monoxide. In either case reduction occurs, and the product is ready for mixing and briquetting. If the last process is performed at great pressure, the admixture of a catalytic agent may be entirely unnecessary. (1,121,048, Dec. 15, 1914.)

Furnace for Heating Billets.—A special type of furnace for heating billets or ingots preparatory to rolling, is patented by Mr. JEROME R. GEORGE, of Worcester, Mass. The furnace consists of a long channel, at one end of which the billets are introduced sideways and caused to travel to the opposite end, where they are removed. Heating gases enter the furnace at the discharge end, and are directed under and around the billets in a manner that gives high fuel efficiency. Near the discharge end of the furnace, the floor is inclined downwardly to facilitate the collection and removal of cinder, slag and molten metal that drips from the billets as they become highly heated. (1,121,621, Dec. 22, 1914.)

Liquid Fuel for Furnaces.—A new process of generating heat, particularly applicable to the melting of metals and smelting of ores, is patented by Mr. BRADLEY STOUGHTON, of New York City. The essential features are the use of fluid fuel to supply all or practically all the heat needed, and the use of a minimum quantity of solid fuel, the function of which is to be maintained incandescent for the purpose of igniting and insuring complete combustion of the fluid fuel without waste. Sufficient air is admitted to insure complete combustion of the fluid fuel and to keep the solid fuel incandescent, it being an object to consume the latter as slowly as possible. The process may be applied to shaft furnaces and some forms of reverberatory furnaces. A heated blast of air may be used, and steam for atomizing the oil. The process may be applied by placing at the bottom of a furnace a thin bed of coke, on this a layer of ore or metal, then a layer of coke, and so on. The coke bed is then ignited and the oil injected into the incandescent mass with sufficient air to insure complete combustion of the oil and incandescence of the coke. (1,117,274, Nov. 17, 1914.)

Making Manganese Steel from Scrap.—In a patent recently granted to Dr. HENRY M. HOWE, of Bedford Station, N. Y., he discloses a method of remanufacturing manganese steel scraps into manganese steel articles in which the necessary critical relation between the proportions of carbon, manganese and iron are maintained. In brief the process consists first in melting and mixing scrap and manganiferous material, such as commercial ferromanganese, in suitable proportions to produce the critical ratio between carbon and manganese in the mixture, with a suitable allowance for the changes in the proportions of these elements which will take place from the reactions incident to melting. In other words, the proportions must compensate for the loss of manganese by oxidation and the gain in carbon by absorption from the fuel. Having established this ratio, the mixture is diluted with carbon-free iron, such as blown Bessemer metal, until the amounts of carbon and manganese bear to the whole the desired percentage relation. The final adjustment of proportions may be made in an open-hearth furnace. (1,117,384, Nov. 17, 1914.)

Removing Rings from Nodulizing Kilns.—In order to remove rings of slagged material accumulating in rotary kilns used for nodulizing iron ores, Mr. FRANCIS B. DUTTON, of Lebanon, Pa., proposes to introduce water under pressure against the surface of the adherent ring. According to the patent specifications this is accomplished by arranging a series of water pipes along the length of the kiln, said pipes being connected with a header and extending through the kiln wall. Water introduced through these pipes under pressure would come in contact with the surface of the hot slagged mass, and by the sudden generation of steam, as well as by the force of the water, the accumulation would be dislodged. The operation is performed in a short space of time, does not allow the kiln to cool to a substantial degree, and eliminates the application of manual labor to the removal of the rings. (1,117,814, Nov. 17, 1914.)

Gold and Silver.

Filtering Apparatus.—Two types of filtering apparatus for slime have been patented by Mr. O. J. SALISBURY, of Salt Lake City, Utah. The first is a filter press consisting of a casing of circular cross-section, and containing the filter leaves or elements suitably connected with a source of vacuum. In order to facilitate the inspection of the press and the discharge of the cake formed on the leaves, the casing or shell is formed of similar sections hinged along an upper median line, and capable of opening and closing in unison. When in the closed position the sections are locked to make a liquid-tight joint. In operation the casing is charged with slime, under pressure, and the filtered liquid passes through the leaves and suitable connections to an outside receiver. The cakes thus formed on the filters are discharged by opening the hinged sections of the casing. (1,120,628, Dec. 8, 1914.)

The second type of filter is cubical in form, the casing consisting of two sides and ends rigidly connected, while two of the sides are designed for removal to form a clear passageway through the casing for the unabstructed discharge of the filter cakes. The casing contains filter leaves or elements suitably connected through a header with an outside receiver. The removable sides are rotatable about the casing, and the entire apparatus may be rotated to bring it into a position for discharge. In both types of apparatus the cakes are formed and washed by hydraulic pressure, and discharged by reverse pressure of a fluid in the filter leaves. (1,120,629, Dec. 8, 1914.)

Copper and Cobalt.

Copper Leaching and Electrolysis.—A hydrometallurgical process for copper sulphide ores patented by Mr. N. V. HYBINETTE, of Christiania, Norway, consists in roasting the ore to a point beyond the formation of Cu_2S but not to complete oxidation, leaching with sulphuric acid and precipitating by electrolysis. The ferric iron salts in the solution are used to dissolve the sulphide of copper remaining in the ore due to incomplete roasting. The inventor states that the disturbing influence of ferric salts on the deposition of copper does not occur before the amount is above 10 gr. ferric iron per litre, and the process does not become practically impossible before the amount rises above 15 gr. per litre. The rapidity of oxidation of the iron salts depends on the amount of ferrous iron in solution, proceeding with almost theoretically rapidity as long as there is present not more than 30 gr. ferrous iron, but ceasing as long as there is only 15 gr. ferrous iron. Therefore as long as there is not much more than the 30 gr. per litre present, the oxidation of iron above 15 gr. per litre as ferric sulphate goes forward very slowly, and the dissolving of the cathodes does not present unsurmountable difficulties at that degree of concentration of ferric salts. At the same time he has found that most of the copper sulphide in the roasted ore is readily soluble in a solution containing 15 gr. iron as ferric sulphate, but insoluble if the concentration falls below 10 gr. per litre. Therefore, by holding the iron content at a concentration of about 30 gr. per litre, the process may be successfully conducted.

The ore is roasted so that about 25 per cent of the copper is present as sulphide, insoluble in 5 per cent sulphuric acid solution. A solution containing about 30 gr. iron and 20 gr. copper as sulphates, and 60 gr.

free sulphuric acid per litre, is circulated between the electrolytic cells and the leaching vats. The solution entering the cells is regulated to contain about 30 gr. per litre, and leaves with about 20 gr. The solution entering the cells contains about ferric iron in quantity from 2 to 5 gr. per litre, and about 15 gr. on leaving. Thus about 10 gr. copper is plated and about 10 gr. iron oxidized. The success of the process depends on roasting the ore to the correct point, and in maintaining the proper amount of iron in solution. The latter is regulated by periodically discarding some of the solution. (1,122,759, Dec. 29, 1914.)

Electrolytic Production of Wire.—An invention relating to the production of copper wire by electrodeposition and drawing, is patented by Mr. William E. Gibbs, of Plainfield, N. J. It has for its object the production of a wire of high electrical conductivity and of superior quality due to the exclusion of impurities occurring in the ordinary drawn wire. The wire is carried automatically through electrolytic vats containing an electrolyte of about 3.5 per cent copper and 10 per cent sulphuric acid at a temperature of about 140 deg. F. (1,120,191, Dec. 8, 1914.)

Reduction of Cobalt.—The reduction of cobalt and similar metals from combinations with arsenic, sulphur and similar metalloids may be accomplished according to a patented process of Dr. Colin G. Fink, of Schenectady, N. Y. He mixes the ore with a reaction mixture which, upon heating, yields a metal having a higher heat of combination with non-metallic elements than that of the metal which is desired to recover. Such a mixture is calcium carbide and calcium oxide, yielding calcium and carbon monoxide. The liberated calcium combines with the metalloid of the ore and liberates the metal. Thus, in the case of cobalt in smaltite

$$2CaO + CaC_2 = 3Ca + 2CO$$
$$CoAs_2 + 3Ca = Ca_3As_2 + Co$$

The process is conducted in a vacuum furnace at a temperature as high as 1500 deg. C. (1,119,588, Dec. 1, 1914.)

Lead and Zinc.

Bag House for Lead Smelter.—Mr. Willard E. Playter, of Collinsville, Ill., has patented apparatus for controlling bag-house operations, causing them to occur automatically in proper sequence. The apparatus is electrically operated and controls the supply of gas and means for shaking the bags. The essential features of the apparatus are a motor and a drum controller provided with contact members. As the drum revolves the contact members cooperate with brushes in circuit with solenoids controlling air valves. These valves operate the dampers that open or close the ports between the flue and the bag-house units, admitting or excluding gas from any unit. They also control the shaking means, which consists of an air chamber above each bag and a depending flexible tube or hose within each bag. When air is admitted to the chambers and passes through the tubes, it causes the latter to vibrate with considerable violence and shake the accumulated dust from the bags into the cellar beneath. The apparatus may be adjusted as regards time so that the different operations occur in proper sequence at stated intervals. (1,118,045, Nov. 24, 1914.)

Electric Zinc Furnace.—A zinc furnace of the resistance type has been patented by Mr. Otto E. Ruhoff, of Madison, Wis. The furnace has a number of charge openings distributed along its top, a set of electrodes at the top in contact with the charge and a corresponding set of electrodes at the bottom. The walls of the furnace are provided with a relatively large number of condensers so that condensation can be accomplished quickly. (1,121,874, Dec. 22, 1914.)

Recovery of Zinc from Waste Liquors.—The extraction of zinc from liquor containing ferrous iron, as in the case of liquors from which copper has been precipitated by means of iron, is patented by Dr. Wilhelm Buddeus, of Charlottenburg, Germany. Both the zinc and iron are precipitated by means of lime, filtered and dried. During the drying process the ferrous iron is oxidized to ferric oxide, and from the resulting product the zinc may be dissolved by means of acid. The quantity of acid used is regulated by the amount of zinc in the mass. The resulting leach liquor is separated and treated as desired to recover the zinc. (1,120,683, Dec. 15, 1914.)

Electrical Precipitation of Suspended Matter

The corona discharge is utilized to precipitate suspended matter from gas, according to specifications of a patent granted to Messrs. William W. Strong of Pittsburgh, and Arthur F. Nesbit, of Wilkinsburg, Pa. The patent is assigned to R. B. Mellon, of Pittsburgh. The effect of the introduction of a spark gap in series with the active or grounded electrode is to extend the luminous region about the active electrode, and this fact is used in connection with the separation of suspended matter from a gas. (1,120,561, Dec. 8, 1914.) Apparatus that will throw on the high tension electric current used for such separation, only when suspended matter of a certain density exists in the gas, is the subject of a separate patent granted to Mr. William W. Strong. (1,120,560, Dec. 8, 1914.)

Electric Treatment of Emulsions and Dusty Gases

Petroleum emulsions can be freed from water by treatment in an electric field in suitable apparatus. The potential between electrodes is maintained sufficiently high to positively cause a puncturing of the oil between the different particles of water, so that they coalesce in a practically continuous chain between the electrodes. When the current is interrupted, the chains coalesce into a globule of water which then drops out of the oil. The patented apparatus and method are illustrated in the specifications. (1,116,299, Nov. 3, 1914.)

The electric precipitation of dust or suspended particles in a gas is patented by Messrs. W. W. Strong, of Pittsburgh, and A. F. Nesbit, of Wilkinsburg, Pa. The patent is assigned to R. B. Mellon, of Pittsburgh. The electrode maintained at a high difference of potential. The grounded electrode is formed in the shape of cells through which the dust-laden gas is passed, and within which is placed the active electrode. The dust is precipitated onto the grounded electrodes or into deposition chambers. (1,119,469, Dec. 1, 1914.)

Metallurgical Furnace

A roasting furnace is patented by Mr. Utley Wedge, of Ardmore, Pa., being of the superposed-hearth type in which stationary hearths alternate with rotating hearths. The rotating hearths are attached to a central rotating shaft. Both the fixed and rotating hearths have depending rabbles attached, so that material fed onto any one of the rotating hearths will be moved outward and discharged over the edge of the hearth onto the fixed hearth below, when it will be moved inwardly to the central point of discharge onto the moving hearth below. (1,119,483, Dec. 1, 1914.)

The Foreign Trade Movement was the keynote of the convention held on January 21 and 22 by the National Foreign Trade Council at St. Louis. President Farrell of the Steel Corporation is the chairman of the Council. Upwards of 300 delegates were in attendance.

Notes on Chemistry and Metallurgy in Great Britain

(From our London Correspondent)

The War and Engineering Industries

Conditions have improved considerably during the last few weeks in the engineering trades generally. At Sheffield there has been a decided advance in almost all classes of work as well as the exceptional briskness due to increased output of war material; while important orders from the French Government are virtually secured. The demand for warlike stores maintains great activity in Birmingham works producing such material; but those not so employed are by no means so happily circumstanced. Very large orders for motor-bicycles have been placed, and over a thousand of these machines are being built for the Russian Government. In South Wales the iron and steel works are growing busier; and the output of railway rolling stock, galvanized sheets, nickel and copper has attained very large dimensions. In the northeastern district manufacturers continue to experience considerable difficulty in securing adequate labor to cope with the Admiralty and War Office orders.

Labor troubles have been threatening at Elswick, but so far the dissatisfaction of the men with certain new conditions has not led to any interruption of work, and the matter appears likely to be smoothed over. On the Clyde numerous contracts for cargo steamers have been placed, and the outlook is very satisfactory. Sir W. G. Armstrong, Whitworth & Co., of Newcastle, have secured the contract for three pairs of gates for the north basin and central dock entrances at West Hartlepool, the order for which material was originally given to a German firm at Oberhausen; and among other contracts transferred from German workshops is one for six locomotives for the Taff Vale Railway which has been placed with the North British Locomotive Company of Glasgow.

* * *

At a meeting of the Birmingham Chamber of Commerce on November 30, the chairman, Mr. Sambridge, said that most of the gloomy forebodings entertained at the beginning of the war had been entirely falsified, and, instead of industries being paralyzed, trade was in a very healthy state, and many firms were encountering great difficulties through shortage of labor. Of course, some trades had been rather badly hit, but even with these there was now an improvement. Closed markets must be replaced by others. There was a great improvement in the financial position with a gradual but steady re-establishment of credit, while exchanges were easier. War was necessarily wasteful, but they must not lose sight of the fact that a very large proportion of the sums of money which the country had to provide would be spent at home and would benefit our industrial population. The action of the Government with regard to aniline dyes might well be extended to other products with advantage to home manufactures.

The Prevention of Explosions in Mines

The Home Office committee on explosions in mines has issued its sixth and final report on the experiments which have been carried out during the last three years at Eskmeals. Three methods of preventing, or, at all events, greatly reducing the risk of explosions are recommended: (1) The maintenance throughout the roads of such a proportion of incombustible dust in a state of fine division as would make a mixture yielding on incineration at least 50 per cent of ash; (2) the maintenance of at least 30 per cent of water in a state of intimate mixture with the coal dust throughout the roads, and (3), a combination of methods (1) and (2), adding the water after the incombustible dust.

Charges of 24 ounces of blasting powder fixed from a cannon in the large gallery at Eskmeals had failed to cause ignition of a mixture of equal parts by weight of coal dust and incombustible dust when the gallery contained atmospheric air only, or when the air contained as much as 2.3 per cent of coal-gas; but when the air contained 2.5 per cent of coal-gas or sufficient firedamp (obtained from Cymmer Colliery, Glamorganshire) to yield 4.6 per cent of methane, the mixture of dusts was ignited, and flame traveled throughout the gallery. No ignition occurred when the air contained 4.5 per cent of methane. The lower limit explosive mixture of methane and air under ordinary conditions requires 5.6 per cent of methane. The efficacy of the incombustible dust appeared to depend more on the degree of fineness than on its composition, and unless the dust contains not much less than 50 per cent by weight of particles capable of passing through a 200 x 200 sieve more than one part of incombustible dust to one part of coal dust is required to prevent ignition. With reground Altofts shale and superfine dolomite dusts containing respectively 55 and 66 per cent of the stated degree of fineness one part to one part of coal dust was sufficient; with flue dust, 31 per cent 200 fine, and dolomite dust, 42 per cent 200 fine; 1½ part to 1 of coal dust was necessary, while three parts of sand, 4 per cent 200 fine, to one part of coal dust was found to be insufficient to prevent ignition.

With regard to watering, experiments conducted by the United States Geological Survey some years ago demonstrated that, in order to prevent propagation of flame, the coal dust must be admixed with about 30 per cent of water, and while this quantity does not produce a wet mixture with fine coal dust, 40 per cent of water produces a muddy mixture. Similar experiments have been repeated at Eskmeals, both with coal dust in its natural state and with mixtures of coal dust and incombustible dust, and the results confirm those arrived at in America. With mixtures of coal dust and incombustible dust the Eskmeals experiments went to show that the amount of water required to render the mixture non-inflammable varied inversely as the total ash of the mixture. The coal dust mixture containing 15 per cent of ash would require the addition of from 25 to 30 per cent of water to render it incapable of propagating flame, and each additional 10 per cent of ash in the mixture reduces the requisite quantity of water by about 5 per cent. The nature of the incombustible dust also has a decided effect. Shale dust absorbed moisture more readily than Fuller's earth and formed a binding material which had an agglomerating effect on the fine coal dust which remained caked after drying.

The committee arrived at the conclusion that a combination of "stone dusting" and watering is preferable to either method alone. The manner in which the water is applied to the coal dust has considerable influence on the quantity required. Mixtures prepared outside the gallery and then spread along it by the hand resisted ignition when 30 per cent of water was present; but the spraying of 30 per cent of water by means of jets or rose sprays on the dust strewn along the gallery would not be equally effective, because watering by such means only moistens part of the dust while most of it is swept from the ledges to the floor, forming pools of water and dry dust accumulation without admixture. But when atomizers, delivering the water as a fine mist, were used, it was established that coal dust moistened with an equal weight of water resisted propagation of flame for more than a short distance, even when the conditions of ignition were severe.

This report would be more satisfactory if it represented the unanimous opinion of all the members of the committee, but unfortunately two members, Professor Dixon and Mr. W. C. Blackett, who are not directly connected with the Home Office, have withheld their approval. Moreover, every practical man will recognize that there would be very great difficulty in uniformly maintaining the conditions recommended by the committee; and the protection afforded would not be continuously effectual.

Copper and Nickel

Application of Chloridizing-Roasting to Separation of Copper and Nickel.—The possibility of treating heavy sulphide ores, such as those of Sudbury, Ontario, containing much iron and small amounts of copper and nickel, by chloridizing and removing the copper, leaving an iron-nickel oxide product suitable for production of nickel-bearing iron by smelting in the blast furnace, has been investigated by Mr. Boyd Dudley, Jr., who presents some of his results in the December, 1914, *Bulletin* of the A. I. M. E.

The author first studied the reaction involving the production of chlorine from sodium chloride by the action upon it of sulphur trioxide and atmospheric oxygen. In the roasting furnace the sulhpur trioxide would be obtained from the decomposition of sulphates formed in roasting the ore, and the oxygen would be supplied from the air in contact with the roast. It appears from his experiments that the rate of reaction becomes appreciable at about 500 deg. C. and increases rapidly with rising temperature. The highest temperature attained was 769 deg. C. Another reaction studied was that involving the combination of sodium chloride, silica and oxygen, to form sodium silicate and chlorine. It was found that up to the temperature at which salt melts, 800 deg. C., salt was not decomposed to an appreciable degree.

Experiments were then performed on the chloridation of copper and nickel oxides, using mixtures of copper and nickel oxide with ferric oxide, silica, ferric sulphate and sodium chloride. With copper only it was shown that the completeness of chloridation increases with increasing temperature (500 deg. C. to 700 deg. C.) and increasing time (2 to 4 hours). Considerable copper was volatilized. With nickel only the volatilization was almost nothing, but the production of water-soluble nickel was small, being only 17.7 per cent at 550 deg. C. When both copper and nickel oxides were in the mixture, a maximum of 3.3 per cent of the nickel was converted into water-soluble and volatile compounds at 650 deg. C.

While these laboratory experiments do not prove the commercial feasibility of the proposed process, they suggest the possibility of effecting a separation and indicate the temperatures at which the roast should be conducted.

British Aniline Industry

In furtherance of the scheme for constituting a purely British undertaking for the purpose of manufacturing aniline dyes and allied products the government proposes to guarantee interest on a million and a half of debenture capital, subject to nomination of two members of the board by the government and to a veto which will insure exclusive and permanent British control. There is also a provision securing uniformity of prices to large and small consumers alike. To this outcome of the negotiations the energetic part played by Lord Moulton has contributed in no small degree.

Hydraulic Disruption in Mining

At a recent meeting of the Society of Engineers, Mr. James Tonge contributed a paper describing a "hydraulic mining cartridge," which, it is claimed, may be very advantageously substituted for blasting in mines of all descriptions, for excavations in rocks, breaking up concrete beds, and similar purposes. The instrument consists of a strong steel cylinder with lateral telescopic rams to give a long thrust. It is made in three sizes varying from 2½ to 4 inches in diameter, with eight rams in the smallest size, six in the intermediate, and five in the largest, and is worked at pressures of from three to five tons per square inch.

The general procedure in working wall coal is to drill a series of holes in the seam, from 6 ft. to 10 ft. apart and 3 ft. to 5 ft. deep, near and parallel to the root, and pump off the holes in succession from the free face of the seam. In headings the coal is undercut and sheared vertically in the middle, when one hole on each side of the shear, close to the fast side, will suffice. One man using one machine can pump 30 to 40 holes per 8-hour shift, and the machine will last, with repairs, from three to four years. A colliery in which over 1000 blasting charges were fired every week has adopted the hydraulic apparatus and entirely discarded explosives. In one 3-ft. seam with four machines in daily use, some 28,500 hydraulic thrusts were made in a year and gave an estimated output of 92,626 tons, about 3¼ tons for each thrust. In another case five machines are getting 450 tons per day with 75 per cent large coal and 25 per cent small as against 65 per cent large when explosives were used. Taking the price of large coal at 13s. and of small at 7s. the increase in value due to the five machines works out at £14 5s. per day, without counting the extra 6d. per ton the coal brought down with the machines commands on account of its superior hardness and freedom from dust.

The paper also gives particulars with regard to excavating rock and removing concrete beds which indicate that the hydraulic cartridge works quite as efficiently for these purposes as in coal mining.

Market Prices

November, 1914

	£	s.	d.
Aluminium ingots, ton lots	88	0	0
Alum, lump, loose, per ton	5	10	0
Antimony, black sulphide, powder, ton	28	10	0
Borax, British crystal, ton	18	10	0
Copper sulphate, ton	20	10	0
Caustic soda, 70 per cent., ton	10	2	6
Copper ore, 10 to 25 per cent., unit	..	..	..
Ebonite rod, lb	..	3	0
Hydrochloric acid, cwt	..	4	6
India rubber, para, fine, lb	..	2	8½
Mica, in original cases, medium ... 3/— to	..	5	0
Petroleum, Russian spot, gal	..	..	8¾
Quicksilver, Spanish, bottle	11	5	0
Sal-ammoniac, cwt.	2	2	0
Sulphate of ammonia, ton	10	17	6
Shellac, cwt.	2	15	0
Platinum, oz., nominal	9	5	0
Tin ore, 70 per cent., ton	..	..	..

Lead opened £18.10.0, was £18.15.0 on the 10th, and remained steady for the ensuing week, then rising to £19.10.0 on the 23d, £19.15.0 on the 24th, at which price it remained to close.

Hematite has been steady at 62/—.

Scotch Pig opened 55/4½ and rose from the 17th, reaching 56/10½ on the 23d and 57/4½ on the 25th.

Cleveland opened 49/— and was stronger after the 16th, rising fairly steadily from 49/4½ on that date to 51/6 on the 24th, but only 51/3 on the 25th. It improved toward the end of the month.

After the 16th the metal exchanged reopened for a short time each morning.

Copper at the end of October was about £55. In the earlier part of the month it ran easier, in anticipation of the settlement, being £50.10.0 on the 10th and about £52 on the 13th. By the 17th it had reached £53 and was £55.5.0 on the 23d, was rather easier on the 26th at £55 and closed (settlement price) £54.5.0.

Tin opened about £133 and was £139 on the 10th, re-

maining about this price to the 17th, when it was £138.10.0. By the 23d it was £139.15.0, £140 on the 24th, and £142 on the 25th. On the 26th it had reached £142.5.0 and closed £142.10.0 (settlement).

A New Continuous Filter

There has recently been installed at the Concentrating Mill of the Pennsylvania Steel Company at Lebanon, Pennsylvania, a continuous filter with several interesting and novel features which should insure for it wide application in many industrial operations. While rotary vacuum filters of various types have been on the market for years, there appears to have been little departure, aside from the mechanical design, in the filtering medium proper, and too little attention has apparently been given to the maintenance of the filter in the most efficient condition.

In principle, this new filter is virtually a wheel with shaft, hub, spokes and rim, rotating one-half submerged in the pulp to be filtered and operated by a vacuum. The hub carries a valve, the integral parts of which register with the port holes in the hub, said port holes communicating with the compartments formed by the radial spokes of the wheel.

The wheel is constructed entirely of cast iron and for convenience, the compartments are cast two to a segment, there being eight segments, or sixteen compartments, each being isolated from the other, communication being only through the port holes in the hub to the valve.

Between the radial spokes, so called, a web, which is cast in each segment, supports the filtering medium proper, this covering both faces of the wheel.

The segments are not truly symmetrical, but radiate from the hub at such an angle as to bring the peripheral end and the hub end to very nearly a horizontal position, three or four inches above a horizontal center line of the wheel.

This is done because the cake discharges at this point and because, by such an arrangement, the entire compartment is immersed in the pulp by the time the hub end is and no vacuum is thereby lost by having a bare plate exposed to the atmosphere. As the wheel rotates, the effect is that the rim end of the segment travels ahead of the hub end.

The wheel may also be built of other material than cast iron, should the occasion require.

Construction of this kind permits of a large filtering area in a comparatively small space, the total thickness of the complete wheel being but eight inches and with a wheel 10 feet in diameter, there is an available filtering area of 150 square feet. One or two wheels may be operated in the same tank, saving thereby considerable floor space and requiring a maximum head room of 11 feet.

The filtering medium proper is "filtros," a comparatively new porous, mineral medium which has been prepared in special segmental shapes for this device and which shapes are bolted on to the faces of the wheel through a center hole in each shape, the retaining washers being countersunk so that both faces present smooth, rigid, permanent and practically indestructible surfaces.

The seams between the segmental shapes, which are very narrow and hardly noticeable in operation, as well as the seams between the filtros and the cast iron portions, are filled with a suitable cement, which makes the confined areas proof against leaks and avoids some of the annoying features, so common to numerous filtering devices.

The advantages of such a porous medium over the usual canvas or other fibrous covers are obvious, as with ordinary care, it should last as long as the iron work itself. No frequent replacement or renewals with the time losses incident thereto, no muddy filtrate from a punctured canvas, no tears or breakage from excessive pressures as numerous tests have shown the material capable of sustaining pressures of 100 pounds per square inch, no taking down for scrubbing or cleaning, as filtros may be scrubbed with wire brushes or given an acid bath, if necessary, in place; the cast iron, of course, preventing the excessive use of strong mineral acids.

Furthermore, filtros can be supplied in such grades of porosity as will make the device applicable to the finest slimes or the coarser concentrates or fibrous pulp, giving in all cases where the pulp permits of proper treatment, an absolutely clear filtrate which requires no further clarification. With the appropriate grade of filtros selected, there is but little tendency for clogging of the porous medium and as noted later, the plates covering each compartment are subjected to a back pressure at a certain point in each revolution of the wheel.

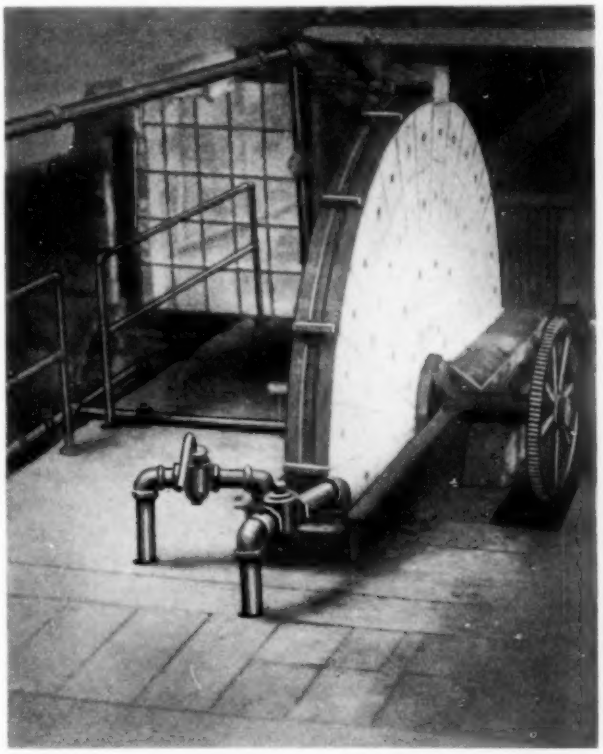


FIG. 1—CONTINUOUS FILTER

For a general cleaning up, a by-pass from the compressed air to the vacuum line permits the entire interior in the wheel and the filtros plates covering it to be thoroughly flushed with air or water. This can be accomplished in ten minutes' time by simply manipulating a few valves, and, depending upon the nature of the pulp being filtered, cleaning should be required only at infrequent intervals.

As stated, the wheel is vacuum operated, the full lower half only being constantly in the pulp. This is made possible by inserting packing collars in the walls of the tank, so that the hub and shaft are partly below the tank top, the said walls being carried to such a hight that there is at least one inch leeway when the wheel is just half submerged.

An over-flow is located at this point on one end of the tank, so that it is impossible to overflow the tank proper.

An outlet is also provided in the tank bottom for discharging the pulp remaining therein should a shut down be necessary, such amount always being small as but about two inches clearance is allowed all around for the wheel.

The wheel so nearly fills the tank that a comparatively small amount of pulp is in it at any one time and the tendency for the pulp to settle and retard the rotation of the wheel or to filter unevenly is thus avoided. Furthermore, the lugs on the rim of the wheel act as rakes for constantly stirring up the pulp and should the occasion require, as may be the case with a very heavy sediment, additional rakes extending both radially and lengthwise, can be attached to said lugs so that settlement of the pulp is impossible, as the sediment would be raked up for the full width of the tank sixteen times for each revolution of the wheel.

Additional agitating devices, which are required in many forms of continuous filters, are thus eliminated.

In the present illustration, the tank does not conform to the circumference of the wheel, though if desirable, it could be made semi-circular.

A door is also located on one side of the tank near the bottom, which is merely for use in emergencies, as when a tool or something of the kind may have been dropped in the tank.

The pulp is fed to the filter tank in the present instance by two three-inch lines directly from the thickeners, though in some installations, an intermediate storage tank with constant level float valve may be desirable. The rate of filtration is so uniform, however, that no difficulty has been experienced in regulating the direct feed line.

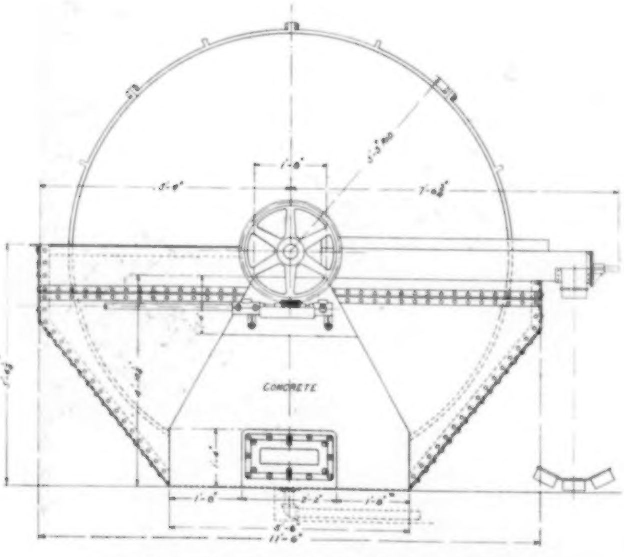


FIG. 2—SECTION OF CONTINUOUS FILTER

The rate of revolution can be varied for most efficient results, these being dependent upon several factors. In general, it has been found that one revolution in three minutes is most desirable, this, with ordinary pulp, producing a cake of such thickness that it is easily discharged from the wheel and also lends itself to easy washing.

All else being equal, the faster the wheel revolution, the greater the tonnage capacity, though not necessarily the most effective results. For example, at the higher speeds, the cake contains more moisture and with the thinner pulps, the cake produced is not so easily handled.

The following brief table, showing some results on a lime sludge, will make these effects clear. The temperature of the pulp was in all cases, 50 F. (which is too low for best results, there being at least 50 per cent increased capacity at 100 F.), the proportion of solids was 36 per cent, liquid 64 per cent and the vacuum 22 inches.

One Revolution of Wheel In	Thickness of Cake	Moisture in Cake	Tons per Hour: Dry Matter	Tons per Hour: Wet Cake
4 min.	About 1"	37%	3.84	6.03
3 min.	About ¾"	39%	4.58	7.56
2 min.	About ½"	40%	5.03	8.44
1 min.	About ¼"	40.5%	5.48	9.28
0.5 min.	About ⅛"	41%	6.30	10.75

As a good illustration of the temperature effects, the following table applying to the same pulp may be cited, all at one revolution of the wheel in three minutes and at 22 inch vacuum.

Temperature, Deg. F.	Moisture in Cake	Tons per Hour: Dry Matter	Tons per Hour: Wet Cake
50	39%	4.58	7.56
61	39%	5.16	8.51
67	39%	6.05	9.99
81	39%	6.64	10.96

from which a marked increase in capacity is noted at the higher temperatures.

But to return to the operation of the wheel. As stated, each of the sixteen compartments communicates independently to the valve, the latter being made for either a right or left hand rotation and having on its outer face, near the bottom, a connection for the main vacuum line. As arranged in the present case, where no washing of the cake is required, fourteen of the sixteen compartments are constantly in communication with this vacuum line, eight of them being submerged in the pulp in forming the cake as they move slowly therethrough and six of them being exposed to the air, the vacuum withdrawing the moisture as far as possible during this exposure.

Where washing of the cake is required and the washings and main filtrate must be separated, an additional vacuum line is attached to the outer face of the valve, so that the last mentioned six segments are independently connected.

Of the two remaining compartments, the one adjacent to these under vacuum, registers with a vent hole in the valve and releases such vacuum as may be retained therein.

This venting arrangement has proved a very economical factor in the operation of the filter as the vacuum is not neutralized by compressed air—which would be the case in the absence of any vent—the compartments in passing the vent hole simply coming under atmospheric pressure, and the sudden shock from vacuum to pressure is thus avoided.

The remaining compartment registers with a compressed-air line attached to a suitable location in the valve and with a pressure of two or three pounds per square inch, the cake is blown off the filter plates clean.

Thus the sequence of operations, as the wheel slowly revolves.

With a three-minute revolution, the wheel is forming the cake for ninety seconds, sucking out the retained moisture for 67½ seconds, releasing the vacuum 11¼ seconds and blowing off the cake for 11¼ seconds.

But very low pressures are required to dislodge the cake owing to its partial release by the vent hole and in the case of certain materials, it may even drop of its own weight.

In any event, just sufficient water to lubricate the face of the filtros plates and allow the cake to slip off cleanly, needs to be blown back. There is but little tendency for even a very slimy cake to adhere to the filtros plates, as the surfaces are smooth and extremely rigid.

Furthermore, what little water is blown back, runs directly down the face of the wheel into the tank as

the scrapers or aprons which catch the cake do not touch the face of the wheel by one-eighth inch or so. This slight back flushing of each compartment at every revolution of the wheel keeps the filtros plates in the highest state of efficiency and as each compartment advances for submergence in the pulp, a clean bare surface is each time presented for a new cake. This feature in connection with the previous remarks respecting the general clean-up maintains the apparatus in a high state of efficiency.

The aprons or scrapers referred to are made adjustable and are attached to and extend over the top of half of the tank on each side of the wheel and conduct the cake into worm-conveyor troughs, similarly located, from which it may be conveyed to cars or stack.

These worm conveyors are driven by chain and sprocket, rotating in the same plane as the shaft which drives the wheel. The shaft of the latter carries a worm gear on the end opposite from that of the valve.

In the present installation, it has not been convenient to determine the actual horsepower required to run the wheel, but it is estimated not to exceed 1 hp, as the wheel is so nearly balanced.

In a total rotating weight of about 9000 lb., only 8 to 11 lb. are lost by removal of the cake from the discharging segment, which, with the gradual loss of moisture from the exposed segments of the wheel, represents approximately the driving power needed.

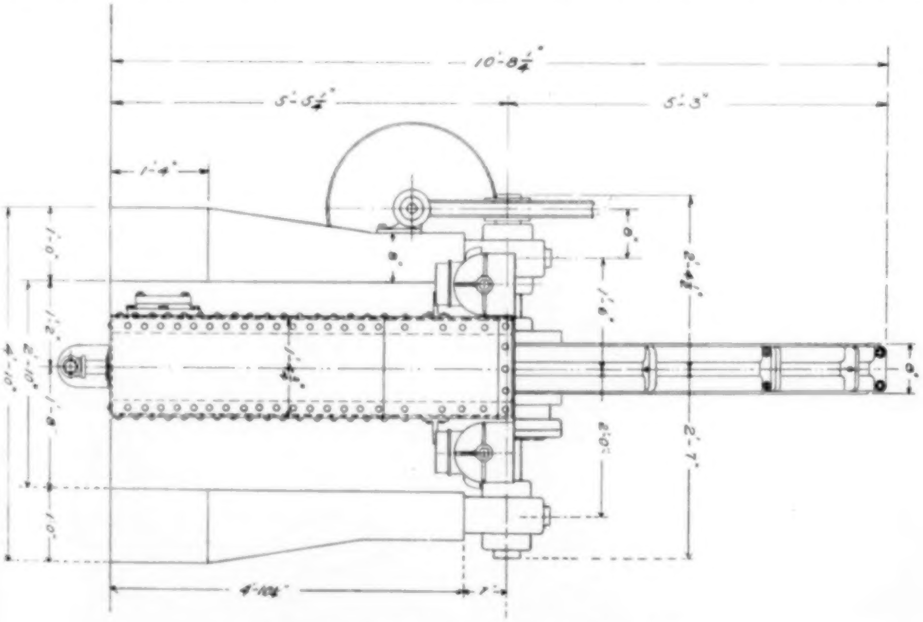


FIG. 3—SECTION OF CONTINUOUS FILTER

The worm conveyors probably require as much power as the wheel proper.

Vacuum pump power is not here considered, as this would be required with any vacuum filter.

Aside from the wear and tear on mechanical parts, the up-keep of this filter is apparently nil, as the permanency of the filtering medium removes the largest item in this respect.

The capacity of the wheel in the present instance has been difficult to estimate accurately, as the density of the feed pulp is constantly varying. The capacity is, furthermore, dependent upon so many factors that it can only be stated that from 45 to 60 tons of dry solids are being handled each twenty-four hours.

The cake was approximately ¼ in. thick at 15-in. vacuum and carried about 27 per cent. moisture; about ⅜ in. thick at 24-in. vacuum and carried 23 per cent. moisture.

In justice to the wheel, it should also be stated that the present proposition is not an ideal one, the mill tailings being filtered, showing on screen analysis but 2.5 per cent. on 100 mesh and 72 per cent. through 200 mesh. Water in contact with them requires a slight acid reaction and the finer portions are of a clayey nature and in a colloidal condition. As an illustration of what may be done under more favorable conditions, some experiments with this pulp showed that by adding one-quarter of 1 per cent. of lime, an increased capacity of 18 to 20 per cent. was obtained on the wheel. As the problem was mainly the disposition of a waste material, however, the lime treatment has not been applied yet.

The present filter wheel is but one of a battery of several to be installed at this plant and is the invention of Col. W. W. Robacher of Rochester, N. Y. The United States and foreign patents are controlled by The General Filtration Company, Inc., of Rochester, N. Y., who are making the present installation.

An Examination of Fire-Bricks

"An Examination of Fire-Bricks and Some Other Technical Refractory Materials" is the subject of a report by **W. Hamilton Patterson** in the (British) Iron and Steel Institute Carnegie Scholarship Memoirs, Vol. 6, page 231, 1914. The author considers only those refractory materials which are cheap and have therefore more general application. The ordinary fireclays are the raw materials from which the majority of these are obtained with or without the addition of other substances, such as ganister or bauxite.

Fire-bricks made from these have wide application and are selected to suit various conditions. Three large industries may be instanced—the production of iron and steel, the manufacture of glass, and the cement industry, with special reference to the lining of rotary kilns for the making of Portland cement.

In each of these industries various conditions obtain, and the refractory material is chosen to comply with them as far as possible.

The author discusses the valuation of fire-brick in three respects:—chemical analysis, specific gravity and limit of refractoriness. Only bricks and materials which may be considered highly refractory, that is, with a melting point of 1600 deg. C. and upward, are considered.

The importance of correct ultimate analyses of clays and fire-bricks made from clays is emphasized. The author proceeded as follows: "The sample is prepared by successive grindings and quarterings, and finally passing through a sieve of at least 90 mesh. It is then, in the case of a fire-brick, dried at about 150 deg. C. to remove any accidental moisture.

"The loss of ignition on 1 gram is determined by heating over the blowpipe flame.

"Half a gram of the sample is fused in a platinum crucible with at least 2.5 grams of fusion mixture ($K_2CO_3 + Na_2CO_3$), the heating being carried out care-

fully over a small Bunsen flame and finally over a full flame.

"The melt is extracted with water and hydrochloric acid, and the whole evaporated to dryness on a water bath. It is moistened with concentrated hydrochloric acid and again evaporated to dryness. Finally, care is taken to evaporate a third time to complete dryness. This can be hastened by placing it in the air oven, but as it is not advisable to ignite the residue at a temperature of more than 111 deg. C. to 120 deg. C., the water bath alone is perhaps preferable.

"*Silica.*—The whole is taken up with hot dilute hydrochloric acid and the silica filtered off and digested with some more dilute hydrochloric acid, and finally washed with hot water until the washings are free from chlorine. This gives nearly the correct amount of silica as slight errors compensate, but its purity may be tested in the usual way by treatment with hydrofluoric acid plus a few drops of concentrated sulphuric acid.

"*Alumina, Ferric Oxide, Titanium Oxide, etc.*—These may be determined together by double precipitation with ammonia, or determined together in one portion of the filtrate, another equal portion of the solution being reduced with hydrogen sulphide, the latter expelled by boiling and passing through carbon dioxide, and finally titrating the iron with N/50 permanganate solution.

"Finally, in a part of the filtrate, usually half the amount taken for either of the above, the titanium is estimated by the well-known color reaction of Weller, by adding hydrogen peroxide, freshly made from sodium peroxide.

"If the iron and titanium are each separately determined from the alumina the precipitate is dissolved for the second time in dilute sulphuric acid instead of hydrochloric acid.

"Calcium oxide, magnesia, and the alkalies are determined by the usual gravimetric methods, the Lawrence Smith method being adopted for the alkalies.

"Titanium oxide is a widely occurring substance and yet it is remarkable that if one looks up the analysis of silicates and clays in various text-books different statements are given as to its estimation. Thus in Lunge, 'Technical Methods of Chemical Analysis,' it is distinctly stated that the titanium comes down with the silica. On the other hand, Treadwell, another authority, in his well-known book on analysis, makes no mention of titanium coming down with the silica at all, but says that it is precipitated by ammonia in the iron and alumina group. The latter statement is the more correct. The following results were obtained in the case of two fire-bricks:

"1. Total weight of silica residue obtained = 0.3643 gram, 2.06 milligrams were left after treating with hydrofluoric and sulphuric acids.

"Of this 0.0005 gram was found to be titanic oxide, which corresponds to 0.10 per cent of titanium oxide in the total fire-brick. But in the same analysis there was also found after separation of the silica as above, with the iron and alumina, titanic oxide equivalent to 1.00 per cent of the total brick.

"2. In this case 0.17 per cent titanium oxide was found with the silica and 0.76 per cent with the iron and alumina. It seems probable that the amount of titanium oxide brought down with the silica increases according to the temperature to which the silica is subjected after evaporation of the hydrochloric acid. The hydrochloric acid used to dissolve the iron and alumina, etc., from the silica after final evaporation to dryness also ought not to be too diluted."

The limit of refractoriness was determined in an electric tube furnace, using a carbon tube with a hydrogen atmosphere.

The test-pieces of the brick, which were small, pointed pieces, were placed in holes in a small graphite boat, as much pointed end projected up as possible. The softening point was recorded when the ends began to bend slightly or round at the top, but as a rule this was not measured, being rather uncertain. The melting point was taken when they collapsed. This, as a general rule, was perfectly definite, and the temperature at which it occurred could be easily defined.

The temperature was measured with a Wanner optical pyrometer. Table I is a list of some of the melting points obtained.

Analyses of some of the samples, the melting points of which are recorded in Table I, are given in Table II.

Table I.—Melting Point

No.	Description	Melting Point, Deg. C.
1	Fire-bricks, ordinary	1620
2	" "	1610
3	" "	1630
4	" "	1610
5	" "	1610
6	" "	1660
7	" "	1680
8	" "	1865
9	" "	1735
10	" "	1860
11	" "	1735
12	" "	1735
13	Dinas silica brick	1680
14	Magnesite brick	1860
15	Special block	More than 1915
16	Bauxite brick	1770
17	Chrome iron ores	1730
18	" " "	1725
19	" " "	1630
20	" " "	1545
21	" " "	1630
22	Bone ash cupel	1865

Table II.—Ultimate Analysis

No.	Specific Gravity	Silica, per cent	Alumina, per cent	Ferric Oxide, per cent	Titanium Oxide, per cent	Total Al_2O_3+ Fe_2O_3+ TiO_2 per cent	Calcium Oxide, per cent	Magnesia, per cent	Alkalies, per cent	Loss on Ignition, per cent
9	2.176	57.0	.....	.....	.....	39.6	0.61	0.45	.....	.....
10	2.139	66.0	.....	.....	.....	31.5	0.44	0.52	.....	0.05
11	2.220	73.2	18.3	6.6	0.40	25.3	0.04	Trace	0.5	0.22
12	2.185	74.4	.....	.....	.....	23.3	0.88	0.45	.....	0.31
13	2.162	96.6	.....	.....	.....	0.35	1.50	0.06	.....	.....
16	2.381	57.1	36.0	4.6	1.44	42.0	0.34	0.06	.....	.....

Fire-Brick for Lining Rotary Kilns.—The question of choosing suitable refractory material for the lining of the clinkering zone of rotary kilns for the production of Portland cement is of interest and importance. As the brick will have to contend against highly basic substances it might be naturally supposed that a basic brick will best fulfil the conditions required.

An examination of a brick which gave very satisfactory results in practice, however, led to the following results:—

	Deg. C.
Melting point	1735
Density	2.217

Ultimate anyalysis—

	Per Cent
Silica	73.2
Alumina	18.3
Ferric oxide	6.5
Titanium oxide	0.4
Calcium oxide	0.4
Magnesia	trace
Alkalies	0.50
Loss on ignition	0.22

The explanation of the success of such a brick for the purpose is given from the fact that it fuses on the sur-

face, and forms with a cement clinker a protective coating which prevents further attack. The question of protective coatings is thus important in judging the practical refractoriness of fire-bricks.

The investigation was carried out in the Muspratt Laboratory of Liverpool University.

A Diatom Heat-Insulating Brick

In the wall construction of furnaces, kilns, boilers, etc., two entirely different problems must be distinguished. One is to provide a refractory lining which will stand the high temperature, the chemical action of the charge, etc., without being destroyed. The other problem is to provide heat insulation, that is, to provide a lining which lets as little heat as possible pass from the inside to the outside. These are two entirely different problems and cannot be solved in general by the same material. In furnace design and construction it is usually very much better to keep the two problems separate and solve each separately, that is, to provide a composite wall consisting of a lining of firebrick or other highly refractory material next to the charge, this backed up by a highly heat-insulating brick, and this again backed up on the outside by ordinary brick.

For the purpose of heat insulation, kieselguhr or infusorial earth has been known for years to be a most excellent material (see, for instance, the extensive article on kieselguhr in our Vol. XII, page 109). But to get kieselguhr in brick form has been a problem in itself and a rather difficult one which has only been solved in recent years. For this reason the following notes on the "nonpareil insulating brick" of the Armstrong Cork Company of Pittsburgh, Pa., should be interesting.

Nonpareil insulating brick is made as follows: Bricks are formed of a mixture of kieselguhr, a small amount of clay, and finely ground cork. The mixture while wet is molded into brick measuring 9 x 4 x 2½ inches, which are dried and then fired. The cork is first carbonized and then gradually burns out completely. In this way, the brick is subjected to uniform heat through its entire mass. The burning out of the cork leaves the brick porous in texture and a light terra cotta in color. The cubical contents of a single brick are 90 cubic inches. The weight averages 1½ pounds. A cubic foot of the material, therefore, weighs approximately 29 pounds.

As to insulating efficiency, the heat conductivity of nonpareil insulating brick is approximately 12 B.t.u. per square foot per degree difference in temperature per one-inch thickness per twenty-four hours. The transmission through fire brick or ordinary building brick will average 120 B.t.u. Thus nonpareil insulating brick transmit one-tenth of the heat transmitted by ordinary building brick; or, in other words, the insulating efficiency of a single course of nonpareil brick 4 inches thick is equivalent to that of 40 inches of ordinary brick.

The high insulating value is due to the structure of the diatoms making up the kieselguhr, as it is composed of the skeletons or shells of almost pure silica, hollow and filled with air, and it is due to the large volume of air confined in minute particles that diatomaceous earth owes its pre-eminence as a natural heat-insulating material.

Being composed so largely of diatomaceous earth which, as just explained, is practically pure silica, nonpareil brick will withstand relatively high temperatures —much higher in fact than any other form of insulation designed for similar purposes. The fusing point is about 1600 degrees F.

Further, nonpareil insulating brick combine insulating efficiency with a sufficient degree of strength to enable their being used as a structural material. While weighing but 1½ pounds each, they will stand a crushing load of 140 pounds to the square inch. They are just as easy to lay as ordinary brick, and in fact, are more readily shaped and cut, where fitting becomes necessary.

Another marked advantage of nonpareil insulating brick as compared with other insulating materials is its resistance to moisture. The brick may be soaked in water or subjected to steam for an indefinite period of time, and after being permitted to dry out will be found to be as strong and efficient as they were before such treatment. There need be no hesitancy, therefore, in employing them in places where they may be subjected periodically to water or dampness.

In installing nonpareil insulating brick the importance of securing continuous insulation—without breaks —should be kept constantly in mind. The brick should be laid in a special insulating cement, which is composed of practically the same substances as the brick themselves and has substantially the same insulating value. Thus nonpareil insulating brick laid with this special cement, provide a solid, unbroken wall of insulation.

As mentioned before, nonpareil insulating brick may be laid between the inside fire brick and the outside common brick, or they can be placed outside the common brick and the exposed surface finished off with a coat of cement plaster. In every case, an inner lining of fire brick must be used, for nonpareil brick are not a refractory material and will not withstand the abrasion to which fire brick are ordinarily subjected.

In recent years the Armstrong Cork Company has evolved a high-pressure covering for steam pipes which is distinctive because it is the only covering made of diatomaceous earth and asbestos. It contains no cork whatever. It is particularly well suited for the insulation of superheated steam surfaces. Moreover, it will bear repeated wetting and drying without injury and for this reason is an ideal form of covering for underground steam lines.

Further information on the use of the diatom insulating brick may be found in the bulletins of the manufacturers, the Armstrong Cork Company of Pittsburgh, Pa., entitled "Nonpareil Insulating Brick," "Comfort and Economy in the Bakery" (heat insulations of bake ovens), "Nonpareil Insulating Brick in Glass Houses," "Permanent Fortifications" (the use of insulating brick in refrigerating plants), and "Saving Fuel" (use of insulating brick for boiler settings).

Paint Remover Patent Decision

The suit of the Chadeloid Chemical Company against the Wilson Remover Company and John MacNaul Wilson for alleged infringement of the Carleton Ellis paint remover patent 714,880 of December 21, 1902, was determined last month in favor of the complainant by Judge Hand in the United States District Court, Southern District of New York. The decree grants the Chadeloid Chemical Company a permanent injunction restraining the defendants from making, using or selling the compositions in issue without license from the complainant and provides for the usual accounting of damages, alleged to have been sustained by reason of the infringement.

Judge Hand, in his decision, says that no successful paint remover had appeared when Ellis set to work. Immediately, his invention went into great use and has substantially controlled the field. All the elements exist which justify one in calling Ellis's patent a pioneer patent.

The decision discusses at some length the contention of the defendant that the "suitable solution" of the patent was not practicable. In final answer to this "it is enough to say that a paste made exactly after the directions of that example was sold under the name

of phenoid and had a successful, though limited, market. However, even if the 'suitable solution' had been very inferior it would have been immaterial if the patent had shown the road to success, as it certainly did. The commercial composition was clearly disclosed, because the patentee gives a large range of equivalents, both in solvents, waxes and alcohols."

"Having determined that the patent is broadly valid because of its basic character, the question arises of infringement. It is quite true that, put in one form, it is accurate to say that Ellis merely omitted one element of the prior art, phenol, but that is a very meagre measure for the real invention. The fact was that the art had relied upon phenol (which no one wanted), because it was at once a potent solver and a non-evaporant. . . ."

"If then it be asked at what point the percentage of phenol avoids infringement the answer is not hard; substantially at that point where the prior art supposed it was necessary, as shown by the lowest percentage it had reached. Since Ellis emancipated the art from the necessity, his monoply should extend to the degree of that emancipation."

Obituary

Charles Martin Hall, whose name will forever be remembered in connection with the foundation of the American aluminium industry, died in Daytona, Fla., on December 27, 1914. At the time of his death he was vice-president of the Aluminium Company of America, but for the last few years he had been in poor health and had been forced to retire to a degree from his formerly very active engineering and business life. As a

THE LATE CHARLES M. HALL

full biographical sketch of Mr. Hall was given in our Vol. I, page 10, only the principal dates of his life will be stated here.

Charles M. Hall was born at Thompson, Geauga County, Ohio, on December 6, 1863. His father was a congregational minister, and moving to Oberlin in 1873, young Hall attended the public schools there and later Oberlin College. There he had one term of chemical study with Professor Jewett and was so captivated with the subject that for nearly a year thereafter he experimented in the Oberlin laboratory, with the special object of finding an electric method of commercially producing aluminium. His experiments were first crowned with success on February 23, 1886, his chief invention being the electrolyte now universally used. Heroult had made simultaneously and independently the same invention in France. To carry out Hall's process, the Pittsburgh Reduction Company was formed in 1888 and began turning out aluminium commercially in November, 1888. The further development of the aluminium industry is history. When Hall started, aluminium was worth about $25 a pound. Hall's later inventions all had some relation to the aluminium industry. He improved especially methods of purifying alumina, baking carbon electrodes, etc. He received the honorary degree of LL.D., from Oberlin College in 1910, and the following year he was awarded the Perkin gold medal from the allied chemical societies of this country. Mr. Hall made his home at Niagara Falls. He was a bachelor.

* * *

Theodore Armstrong, president of the Pennsylvania Salt Manufacturing Company, died on January 5, at his

THE LATE THEODORE ARMSTRONG

residence in Philadelphia, aged 71 years. He had been in failing health for some time. He was born in New York and served in the army during the Civil War. After the close of the war he obtained a position to audit the accounts of internal revenue collectors in Philadelphia and neighborhood. Soon after he became connected with the Pennsylvania Salt Manufacturing Company, and later was appointed chief accountant of the company's works at Natrona, Pa. Seven years later he was made chief auditor at the Philadelphia offices of the company and later became successively secretary, treasurer, vice-president and president. He was chosen president in 1888, and had since held that office. Under him, the management of the company was practically reorganized and many improvements made in its operation and general business, constituting it one of the foremost concerns of its class in the country. Mr. Armstrong was also president of the Wedge Mechanical Furnace Company and a director in several other companies. He had been, for several months, too sick to attend to business and Joseph Moore, Jr., was chosen president pro tempore to perform his duties. He was a member of the Society of Chemical Industry, the American Chemical Society, the National Geographical Society and of many clubs and societies in Philadelphia, where he leaves many devoted personal friends.

Concrete Pumps

Reinforced concrete pumps are the subject of quite an interesting new invention of Mr. Henry De Huff of Philadelphia. They are furnished built complete in place by the D'Olier Centrifugal Pump & Machine Company of Philadelphia, or, if desired, this company furnishes the necessary iron parts and reinforcing bars with complete drawings for the concrete work. This invention is of especial interest in connection with very large capacity pumping projects such as dry docks, drainage and irrigation work. The concrete construction renders practicable the use of pumps of larger capacity that have heretofore been practicable, so that pumps having a discharge connection 10 feet in diameter or larger can be built. The pump is provided with stationary rings with which the pump impeller forms a close clearance and these rings serve as anchorage for the reinforcing bars and a means of centering the concrete. We reserve a more detailed description for our next issue.

Personal

The Anaconda Copper Mining Co. has made some changes in its technical staff recently. Mr. **Frederick Laist** will be metallurgical manager for the plants at Great Falls and Anaconda, having supervision over construction and technical matters. He is succeeded as general superintendent of the Washoe plant by Mr. **L. V. Bender,** who has as assistant Mr. **H. S. Ware**. The business of the Great Falls and Anaconda plants will be in charge of Mr. **C. W. Goodale** and Mr. **E. P. Mathewson** as heretofore.

Mr. **Albert Burch** has resigned his position as general manager for the Goldfield Consolidated Mines Co., being succeeded by Mr. **J. W. Hutchinson.** The position of assistant general manager vacated by Mr. Hutchinson will be filled by Mr. **K. M. Simpson.**

Mr. **Noel Cunningham** is engaged in professional business in the southwest, with headquarters at Douglas, Ariz.

Mr. **A. E. Drucker** has gone to Colombia to build a cyanide mill for the Frontino & Bolivia Gold Mining Co.

Mr. **N. V. Hansell,** of Hamilton & Hansell, 50 Church Street, New York, sailed on Saturday, the 23rd inst., for Europe. He expects to visit England, Russia and the Scandinavian countries before returning to New York.

Mr. **G. J. Kapteyn** has gone to Colombia as superintendent of the cyanide mill of the Bar Principal Mining Co.

Mr. **O. M. Kuchs** has been promoted from assistant superintendent to superintendent of the Toledo smelter of the International Smelting & Refining Co.

Messrs. **John D. Ryan, Benjamin B. Thayer** and **C. K. Kelley** of the Amalgamated and the Anaconda copper companies were in Great Falls, Mont., on a trip of inspection of the smeltng and refining property and conference regarding its future.

Mr. **W. G. Swart** has accepted appointment as consulting engineer for the Hardinge Conical Mill Company, devoting only a part of his time to his new duties and retaining his connection with the American Zinc Ore Separating Company in Denver.

Mr. **C. C. Titus,** manager for the Northwest Metals Co., of Helena, Mont., has been spending several weeks in Denver.

Mr. **Charles S. Witherill** has gone to Chuquicamata, where he will act as general superintendent of the reduction plant of the Chile Exploration Co. He was formerly superintendent of the copper department of the Balbach Smelting & Refining Co. He will be assisted by Mr. **L. M. Green** in charge of leaching, with Mr. **M. R. Thompson** in charge of the electrolytic tank house and Mr. **Otto Koch** in charge of smelting and melting.

Digest of Electrochemical U. S. Patents

PRIOR TO 1903.

Arranged according to subject-matter and in chronological order.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.

Electroplating (Concluded)

672,074, April 16, 1901, George D. Burton, of Boston, Mass.

Relates to an apparatus in which currents of electricity are used in connection with a saponaceous fluid for cleansing cloth, wool, cotton, yarns, or other articles; and it consists in applying to a tank containing a suitable detergent solution, electrical conductors for electrolyzing and heating the solution. The apparatus consists of a tank containing an inner adjustable compartment, having perforated walls, and within which are the articles to be cleaned. Adjacent the ends and bottom of the inner compartment are conductors, so proportioned that a part of the current flows through the conductor, thereby heating the solution, and the remaining part passes from one end conductor through the solution to the other end conductor. The current passing through the solution is said to act on the solution and the articles and cleanse and improve them. The solution may be water, or a weak solution of sal-soda, borax, concentrated lye, or other saponaceous or alkaline liquid.

678,383, July 16, 1901, Ferdinand Eppler, of Berlin, Germany.

Relates to a process of metal ornamentation, by undercutting grooves for inlaid work, and depositing metal in the undercut grooves. The grooves may be partly filled with strips of wire cloth, which effects an economy in metal deposited; and when the grooves are cut in non-conducting material, such as granite, etc., the strips of wire cloth serve as conductors. A number of ways are suggested for securing the conductor, and also to produce ornamental effects.

687,386, Nov. 26, 1901, Botho Schwerin, of Munich, Germany.

Relates to the extraction of sugar from saccharine matter, such as beet-root, sugar-cane, sorghum, and the like, by the electric current. The substance containing the sugar is disintegrated, or finely subdivided, and enclosed in a wet state between a porous diaphragm and a permeable electrode connected as cathode; the anode is placed within a compartment containing water, with a body of water between it and the diaphragm. Upon passing the current, acidic elements are transferred to the anode compartment, while water, alkaline components, and soluble albumen compounds, together with the sugar, pass through the permeable cathode. It is stated that the electric current does not "invert" the sugar. The sugar is separated from the liquor containing it, and from the other substances present, by known methods.

688,857, Dec. 17, 1901, Warren Johnson, of New Orleans, La.

Relates to correcting the weights of metal blanks for coins, etc. In practice, the blanks vary in weight, some are too heavy and others too light. The heavy blanks are placed in a holder and connected as anode, the light-weight blanks being connected as cathode, and both im-

mersed in a suitable electrolyte, the current removing the excess metal from the anode and depositing it upon the cathode; or the blanks may be connected up with ordinary anodes and cathodes to correct their weight.

691,803, Jan. 28, 1902, William F. Patton, of Toledo, Ohio.

Relates to making seamless hollow spheres for floats for steam or water traps. A hollow sphere of paraffin is first made by pouring melted paraffin in a sectional mold and rotating the mold to form the paraffin sphere. After cooling the paraffin sphere is removed, a connecting nipple attached, and the sphere coated with plumbago and "iron by hydrogen," after which it is immersed in a solution of copper sulphate to give it a chemical deposit of copper. It is then electroplated to the desired thickness, the electrodeposit making a firm joint with the connecting nipple. After electroplating the paraffin is melted and run out through the nipple.

694,658, March 4, 1902, Jules Meurant, of Liege, Belgium.

Relates to processes of electrodepositing metals, and to electrolytes in which "addition agents" are added. A variety of addition agents are mentioned, including carbohydrates, organic acids, gums, gelatine, etc. Specific examples are given for zinc, tin, nickel, copper, and silver. With zinc, it is stated that a steel tube, zinc plated, was crushed and then folded upon itself without the deposit stripping. The patent should be consulted for details.

703,857, July 1, 1902, Constantin Jean Tossizza, of Paris, France.

Relates to a process of electrodepositing metals, such as zinc, nickel, cobalt, and cadmium, from solutions containing sulfurous acid, which consists in electrolyzing a solution of zinc sulfate with copper anodes, requiring a minimum voltage of 1 1/10 volts, up to about 1 5/10 volts, with a current density of 40 amp per square meter. The solution containing copper sulfate, after charging with sulfurous acid, is now separately electrolyzed with insoluble anodes, requiring a minimum voltage of 31/100 volt, up to about 5/10 volt. The acid liquor obtained, sulfuric acid, is used to dissolve more ore. Taken together, the two operations permit the electrolysis of zinc at a voltage which is the sum of these two operations, a minimum of 1 4/10 volts, and with acceptable current densities, about 2 volts. See patent No. 710,346.

705,456, July 22, 1902, Duncan Sinclair, of Coalbrookdale, England.

Relates to producing an iridescent coating upon copper, bronze, or like surfaces. The article is first thoroughly cleaned, then connected as an anode and suspended in a solution made of 14 oz. of caustic soda, 10 oz. litharge and ½ gal. of water, boiled for one hour, and then diluted to a gallon. To the above solution is added a small proportion of copper-plating solution, which is made as follows: dissolve 1 lb. of potassium cyanide in 1 gal. water, suspend a weighed copper anode sheet therein and pass a current from the copper until the solution contains 3 oz. of copper to the gallon. A current is passed from the copper article to be made iridescent as anode in the above solution for a time and at a current density depending upon the graduation of color desired. When this is reached, it is taken out, thoroughly dried, and may be subjected to heat varying according to the effect desired, from 150 deg. Fahr. to 500 deg. Fahr. The heating intensifies the color of the iridescent coating which is said to consist of an oxide of lead containing copper.

710,346, Sept. 30, 1902, Constantin Jean Tossizza, of Paris, France.

Relates to electrodepositing copper from the sulfate solution resulting from the treatment of roasted copper ores with sulfuric acid. The sulfate solutions thus obtained contain besides copper, sulfate of iron, and other metals. During electrolysis, the voltage tends to rise, resulting in the depositing of other metals, and finally spongy iron. The present invention relates to electrolyzing such impure solutions with carbon anodes, and depolarizing the same with sulfurous acid, either as a gas or liquid, which may be passed into a hollow anode, or over the outer surface thereof. The sulfurous acid is oxidized to sulfuric acid, and reduces the voltage required to electrodeposit the copper, with working current densities, to 6/10 volt. The sulfurous acid is obtained by roasting sulfid ores. See patent No. 703,857.

713,277, Nov. 11, 1902, Anson G. Betts, of Lansingburg, N. Y.

Relates to electrodepositing and refining lead and its alloys. The electrolyte described in his prior patent, No. 679,824, dated Aug. 6. 1901, is used, to which is added a reducing agent, such as gelatin, pyrogallol, resorcinol, saligenin, ortho-amido-phenol, hydroquinone, and sulfurous acid. Of these gelatin is the cheapest and gives the best results. One part of gelatin is dissolved in hot water and added to 5000 parts of solution. A current density of 10 to 20 amp per square foot of cathode surface is used. A product is easily made with a specific gravity of 11.36, the same metal remelted and cast having the same density. With higher current densities the lead becomes harder and more brittle. A sample deposited with a current density of 40 amp per square foot showed a specific gravity of 11.276. The presence of the reducing agent serves to restrain crystallization of the deposit. Gelatin and pyrogallol give projections that are nodular on thick deposits. See patent No. 713,278.

713,278, Nov. 11, 1902, Anson Gardner Betts, of Lansingburg, N. Y.

Relates to electrodepositing and refining lead and its alloys, and claims the product produced by the process described in his co-pending application, which became patent No. 713,277.

716,306, Dec. 16, 1902, Otto Carl Strecker, of Cologne, Germany.

Relates to preparing printing plates by electrolytic etching. The plate properly prepared and coated with a resist is connected as an anode in an electrolyte, which for a zinc plate may be a 2½ per cent solution of fluoride of sodium, a current density 0.5 amp to 0.9 amp per square foot being used for from two to five minutes. The patent should be consulted for details.

Book Review

Laboratory Course in Electrochemistry. By **Oliver P. Watts,** of University of Wisconsin. 150 pages, 16 illustrations; price, $1. New York: McGraw-Hill Book Company, Inc.

This book contains in abridged form directions for 133 experiments illustrating elementary principles and some advanced principles of the electrolysis of solutions and of fused salts. Electric furnace operations and detailed electrochemical analysis are not considered.

The dominant idea of the book is to guide students into observing and understanding the real principles involved in electrolysis. Assuming, of course, that they have a competent and enthusiastic instructor, Dr. Watts' book is admirably suited to its purpose. It is clear, direct, stimulating to observation and thought, and puts more weight on principles than on details, on contriving with simple apparatus than on merely using expensive special apparatus. We heartily commend the book to all beginning work in the electrochemical laboratory.